BLM

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Preliminary Environmental Assessment
DOI-BLM-CA-N020-2025-0001-EA

Carter Reservoir, Buckhorn, and Coppersmith Wild Horse Gather and Population Control Plan

October 2025

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1.0 Introduction

The Bureau of Land Management, Applegate Field Office (BLM) is proposing to immediately gather and remove excess wild horses and burros from within and outside the Carter Reservoir, Buckhorn, and Coppersmith Herd Management Areas (HMAs; hereafter referred to as the HMAs). This would bring the population to the low range of the established appropriate management level (AML). BLM also proposes to implement a range of fertility controls to reduce the rate of population growth and manage the population within AML to allow for recovery of deteriorated rangeland resources. While the HMAs are not managed for burros and no burros were observed in the population overflights, it is possible that some burros could be present in the gather area due to proximity to Twin Peaks and any burros would be removed as excess if found.

Aerial surveys would be conducted before gathers to provide up-to-date information about the local population size in each HMA and approximate locations of the animals. The specific number of excess animals gathered and removed to achieve and/or maintain AML would depend on when the actions occur and how many wild horses and burros are inhabiting the HMAs. Female horses returned to the HMAs would be treated with an approved fertility control method in accordance with current BLM policy and guidance.

In compliance with the National Environmental Policy Act (NEPA), this Environmental Assessment (EA) is a site-specific analysis of potential impacts that could result from implementation of the Proposed Action or alternatives. If the BLM determines significant impacts could occur, an Environmental Impact Statement (EIS) will be prepared for the project. If no significant impacts are expected, an EIS will not be prepared, and a decision will be issued along with a Finding of No Significant Impact (FONSI) documenting the reasons why implementation of the selected alternative will not result in significant environmental impact.

1.1 Background

As designated in the 2008 Surprise Field Office Resource Management Plan (RMP) and Record of Decision (ROD; BLM, 2008a), the three HMAs are administered by the BLM Applegate Field Office: Carter Reservoir, Buckhorn, and Coppersmith HMAs. The Buckhorn and Coppersmith HMAs are adjacent to one another and the Twin Peaks HMA to the south (which is managed by BLM Eagle Lake Field Office). The Carter Reservoir HMA is relatively more distant from Coppersmith and Buckhorn HMAs, but closer to the Massacre Lakes HMA and Bitner HMA. Aerial survey observations confirm that wild horses have expanded significantly outside the Carter Reservoir HMA boundaries to the north, south, and west. There have not been documented Carter Reservoir horses moving into other HMAs. Given the proximity and similarities in BLM action and affected environment, previous BLM management actions have combined these HMAs into single NEPA analyses such as in the 2009 Buckhorn, Coppersmith and Carter Reservoir Wild Horse Herd Management Areas Capture and Remove Plan Environmental Assessment (DOI-BLM-CA-N070-2009-11-EA). Many of the management considerations are common to all three HMAs, and this EA notes and analyzes any instances where those considerations would be distinct for one or another HMA. See Appendix C for a complete list of previous NEPA documents that are hereby are tiered to and/or incorporated by reference.

The HMAs lie in northwestern Nevada mostly in Washoe County, Nevada with small portions in Modoc and Lassen County, California. The HMAs, combined, are approximately 46 miles long from north to south and 40 miles wide east to west. The HMAs stretch from the Oregon border south through the Hayes Range to Nevada 447 and from Duck Flat to the west towards McDonald Mountain. The total acreage of the HMAs is 196,181 acres of public and private lands and consists of a vast, diverse, and remote landscape. However, wild horses from the HMAs now occupy an additional 281,000 acres beyond the HMA boundaries (Table 1-1; estimated from horse observations from census efforts).
The HMAs contain many unique and important biological, geological, scenic, and cultural resources. Besides providing forage and habitat for wild horses, the HMAs contain important habitat for several

wildlife species, including the greater sage-grouse, pronghorn, and mule deer. The other predominant land uses within the HMA are livestock grazing, back country recreation, and general recreation, including hunting.

Table 1-1. Acreages of Federal and Non-Federal lands for the HMAs. Acres listed in column 4 are additional acreage affected by wild horses that have moved beyond HMA boundaries.

HMA	BLM Acres	Non-BLM acres	Total acres	Approximate acres outside HMA occupied by wild horses
Carter Reservoir	21,074	2,349	23,423	250,000
Coppersmith	73,547	13,273	86,820	1,000
Buckhorn	76,550	9,388	85,938	30,000
Total	171,171	25,010	196,181	281,000

Across all three HMAs, the aggregate AML range is 134-195 wild horses and zero burros, with Carter Reservoir HMA's AML range of 25-35, Buckhorn HMA's AML range of 59-85, and Coppersmith HMA's AML range of 50-75 (Table 1-3). The AML upper limit is the sum-total of the maximum number of wild horses that the HMAs can support while maintaining a thriving natural ecological balance and multiple use relationship on the BLM-administered lands in each of the HMAs. Establishing AML as a population range with a lower limit of AML as well allows for the periodic removal of excess animals (to the low range) and subsequent population growth (to the high range) between removals. The AML for each HMA was established independently and those AML levels are the target herd sizes for wild horses at the scale of the specific individual HMAs. The AML for each HMA was determined based on in-depth analyses of habitat suitability, resource monitoring, and population inventory data with public involvement. The background history on AML establishment and subsequent decisions can be found on page 4 in the 2009 Buckhorn, Coppersmith and Carter Reservoir Wild Horse Herd Management Areas Capture and Remove Plan Environmental Assessment (DOI-BLM-CA-N070-2009-11-EA), which is incorporated into this assessment by reference.

Carter Reservoir HMA Appropriate Management Levels

The Carter Reservoir Herd Management Area (HMA) is located about 6 miles east of Cedarville, CA, beginning at roughly the California/Nevada state line on the east side of Surprise Valley in Modoc County and extending approximately 6 miles northeast into Washoe County, Nevada (Figure A-1). The HMA consists of approximately 21,074 acres of public lands and 2,349 acres of fenced and unfenced private lands. The elevations vary from 4,500 feet in Surprise Valley to 6,300 feet on the Hays Mountain Range.

The Carter Reservoir Herd Management Area AML is 25-35 wild horses and was established by the Capture Plan and Environmental Assessment #CA-370-03-19 (June 2003). Although some level of Spanish breed genetic influence in this herd may exist, horses from this herd were never listed in reports from Cothran (Appendix L) or the National Research Council of the National Academies of Sciences (2013) as having a notably high level of such influence. In his analysis of 2010 samples from Carter Reservoir HMA, (see Appendix L), Cothran noted that "The most likely ancestry based upon the total analysis is of North American breeds."

The AML for the Carter Reservoir HMA was based on resource monitoring data collected on the HMA from 1990 through 2003. The key limiting factors for wild horses within this HMA include: 1) the use of privately owned riparian areas by wild horses, 2) a limited supply of available public water to support wild horses, and 3) areas of upland heavy utilization. Another consideration was the egress of wild horses to an adjacent allotment outside of the herd management area.

The Carter Reservoir HMA was last gathered in 2009, and a total of 152 horses were removed. The last aerial census of the Carter Reservoir HMA was conducted in May 2022, at which time a total of 424 horses (including foals) were estimated in the surveyed area, of which 240 were counted outside the HMA boundary (Crabb, 2022b). Following the Calico/Surprise Wild Horse and Burro Gather in 2023, a post-gather flight was completed, which included the Carter Reservoir HMA (Crabb, 2022c). The current estimated population of 330 horses is based on flight data, including outside HMA areas, as well as additional ground observations. However, due to inclement weather, approximately 30% of the area related to the Carter Reservoir HMA was not flown, as compared to the May 2022 flights. The 2023 flights over Carter Reservoir show horses outside the transects of the south and west end, which suggests that horses may have traveled further south and west into areas that were not surveyed. BLM intends to conduct another flight inventory prior to gather operations. The computer simulation Summary of Population Modeling of Wild Horses can be found in Appendix A.

Buckhorn HMA and Coppersmith HMA Appropriate Management Levels

The Wild Horse Gather and Removal Plan Decision of November 1995, (Environmental Assessment #CA-028-95-08), which is incorporated into this assessment by reference, established the Appropriate Management Level (AML) at 59-85 wild horses in the Buckhorn HMA and 50-75 wild horses in the Coppersmith HMA. Horses in these two herds display a range of coat colors and, as with wild horses in the Carter Reservoir HMA, horses in these two HMAs appear to have mixed ancestry that is most similar to various North American and light riding breeds (Appendix L). The AMLs were established using monitoring and resource data collected on the HMAs from 1987 to 1995.

The east boundary of the Buckhorn HMA is Nevada Highway No. 447, at Duck Flat Valley (elevation of 4,700 feet), located in Washoe County, Nevada and extends west to the Cottonwood Mountains (elevation of 7,240 feet) in Lassen County California (Figure A-1). The HMA contains approximately 76,550 acres of public lands and 9,388 acres of private lands. Some of this private land is fenced, but also includes unfenced and intermingled private land parcels varying in size from 40 acres to over 640 acres. The adjoining HMAs include the Twin Peaks HMA, which is located to the south of the Buckhorn HMA. The Surprise/Eagle Lake Field Office division fence separates these two HMAs. The Buckhorn HMA is adjacent to the Coppersmith HMA. Tuledad Canyon and a pasture division fence within the Tuledad Allotment is the boundary between these two HMAs.

The Coppersmith HMA is in Lassen County, California and Washoe County, Nevada from Duck Lake, and NV highway 447, west to lower slopes of the Warner Mountains (Figure A-1). The HMA consists of approximately 73,547 acres of public lands and 13,273 of other lands, which are mostly private. Elevations range from 4,700 feet on Duck Lake to 8,000 feet on the south end of the Warner Mountains.

Adjacent Lands Outside of HMAs

The public land portions outside the boundaries of the three HMAs are areas that did not have wild horses at the time of passage of the Wild Free-Roaming Horses and Burros Act of 1971 (as amended), or that have been determined through the BLM Land Use Planning process to not be suitable for wild horse use. As such, these areas are not managed for wild horses and applicable laws, policies, regulations, and land use plans direct that any wild horses found on these lands are excess and should be promptly removed. See Appendix B for a map of observed animal group locations both on- and off-HMAs, noted in 2022 aerial surveys.

Past Actions

The 2009 Buckhorn, Coppersmith and Carter Reservoir Wild Horse Herd Management Areas Capture and Remove Plan Environmental Assessment (DOI-BLM-CA-N070-2009-011-EA) is hereby incorporated by reference.

The HMAs were last gathered in 2009 (Table 1-2) which is also the last year each HMA administered PZP vaccine (Porcine Zona Pellucida, PZP-22) to mares. Released mares and studs received a freeze mark for future identification.

Table 1-2. The 2009 gather and release statistics.

2009 Gather Numbers	Gathered (Total)	Released (Studs)	Released (Mares PZP)
Carter Reservoir	157	1	3 (untreated)
Buckhorn	236	11	22
Coppersmith	130	0	0
Total	523	12	25

Current Population Estimate

The most recent complete aerial survey within and outside the HMAs took place in April 2022, with two separate flights; Buckhorn and Coppersmith were flown in conjunction with the Twin Peaks HMA inventory flights (Crabb, 2022a) and Carter Reservoir was flown in May of 2022 along with remaining HMAs within the Surprise/Calico Mountain HMA Complex (Crabb, 2022b). Additionally, the southern end of Buckhorn HMA was also flown in September 2022, after the Twin Peaks WH&B Gather (Crabb, 2022c).

Inventory numbers are based on an aerial survey observation using the simultaneous double-observer counting method (Griffin et al., 2020). Statistical analysis of data to account for animals present, but not seen, led to an estimated total of 724 wild horses in the HMAs at the time of the 2022 surveys – implying that observers saw approximately 90% of horses present. It is also likely that the 2022 survey population estimates are *lower* than the actual number of animals present within and outside of the HMAs because of known tendency for the double-observer analysis to lead to underestimating true herd sizes (Crabb, 2022a, 2022b, 2022c). Additionally, the spring censuses were completed prior to the end of the foaling season, so there were likely additional foals born after the completion of the 2022 surveys (Crabb, 2022a, 2022b). The estimated number of animals in and near the HMAs based on statistical analyses from the 2022 population surveys (Crabb, 2022a, 2022b, 2022c) was more than 500% over the lower AML for wild horses, and there is no evidence to suggest that the herd sizes have decreased since then on their own.

It should also be noted that the Carter Reservoir HMA was previously flown with a fixed-wing aircraft (i.e., a small airplane) from 2012 through 2019, in accordance with an administrative arrangement called the tri-state WH&B flight agreement between BLM offices in California, Nevada, and Oregon and an office of the US Fish and Wildlife Service (Tri-State Flights). BLM California Applegate Field Office and BLM Nevada Black Rock Field Office started a combined flight census beginning in 2021. The recent change from fixed-wing aircraft to helicopter rotor wing has allowed for lower elevation flights and maneuverability through steep canyons and draws where horses may not have been observed during Tri-State Flights.

Compared to the estimated herd sizes that came from fixed-wing counts in 2019, the number of horses observed in and around Carter Reservoir HMA 2022 reflects a significant and unexpected increase (Table 1-3). However, the numbers and locations of horses seems to coincide with ground counts from both BLM and public land users. The level of herd size increase from spring 2019 to spring 2022 at Coppersmith and Buckhorn HMAs is more in line with expectations consistent with annual growth rates of 10-15%. Population census flights are expected to continue on an approximately 2–3-year cycle.

Table 1-3. Estimated herd sizes, based on statistical analysis of double-observer observations made during aerial surveys from 2010 – 2023.

HMA	AML	*2009	2011	2012	2013	2014	2015	2016	2017	2019	2022	2023
**Carter Reservoir	25–35	106	111	113		157		176		221	424	***221
Buckhorn	59-85	182			145		168		237	174	216	
Coppersmith	50-75	115			56		99		91	63	84	
Total	134-195	403								458	724	

*2009 Pre-Gather Flight Census Count
**Population includes horses outside the HMA.
***Approximately 30% of the targeted flight area outside the HMA was not inventoried due to inclement weather.

As mentioned within Table 1-3, BLM was unable to complete the flight inventory for Carter Reservoir HMA in 2023, due to inclement weather preventing safe helicopter operations. Approximately 30% of the outside-HMA area was not inventoried. Based on the partial aerial survey and supplemental ground-based observations, the BLM estimates that the most likely number of animals present in late 2023 and into early 2024 was approximately 330 horses within and outside the Carter Reservoir HMA. Horse locations for the 2023 flights over Carter Reservoir show horses on the outside transects of the south and west end, which leads us to consider that horses may have traveled further south and west into areas that were not flown. This could also be said for the areas northeast outside of the HMA. This estimate takes into account previous flight inventory numbers, horses counted during the 2022/23 flight inventory and on-the-ground observations from local BLM personnel. Estimated herd sizes in Table 1-4 reflect the BLM's best available estimates of March 2024 herd sizes for the number of horses that are yearlings or older, which are considered adults for management purposes (BLM, 2010). These values are informed by estimates from 2022 and 2023, and the application of a 20% annual growth rate used to estimate 2024 numbers. However, a 15% per year annual growth rate may be more accurate for future projections based on data collected from other HMAs located within Applegate Field Office; 15% was used for the PopEquus projections in Appendix M. It can be difficult to estimate the annual growth rate accurately, as the amount of movement between Twin Peaks horses to the south of Buckhorn and Coppersmith can vary annually, as can the fraction of off-HMA horses in Carter Reservoir. The values in Table 1-4 do not include foals that are expected to be born in the spring of 2024. By October 2024 those foals may increase the number of horses in each HMA by approximately 10%-15%.

Table 1-4. Estimated wild horse population sizes as of March 2024.

HMA	March 2024 Estimated number of adults
*Carter Reservoir	330
**Buckhorn	306
**Coppersmith	116
TOTAL	752

*Based off BLM's estimated number of 330 from 2023 survey and ground counts.
**Based off April 2022 flight inventory estimate and 2023 foaling seasons.

BLM will continue to schedule flight inventories over the next few years and would complete a pre-gather flights as annual gather schedules are approved. While it is clear that the numbers of horses in each HMA are far greater than AML at this time, aerial surveys events would provide more up-to-date population size estimates before the initial and any future gathers.

Proximity to Other HMAs

The Buckhorn and Coppersmith HMAs and the Twin Peaks HMA are adjacent to each other and are separated by an administrative boundary fence. There is some wild horse movement (crossover) between those three HMAs; even though the frequency and extent of that movement has not been precisely quantified, it is reasonable to assume that past and future movements between Coppersmith, Twin Peaks, and Buckhorn HMAs would likely remain high into the future. As some indication of this movement, patterns of census-based herd size estimates have displayed spikes in population growth within the North Observation Home Range of the Twin Peaks HMA, whereas numbers in Buckhorn and Coppersmith tend to show small increases. Throughout the years BLM has noted the administrative boundary fence to be down or in need of repair. This is mostly noted during heavy winters. In contrast, the boundaries of Carter Reservoir HMA are not contiguous with another HMA; Massacre Lakes HMA is 10 miles to the east, and Coppersmith HMA is 20 miles to the south. As such, the expected level of wild horse movements from nearby HMAs is lower than for either Coppersmith or Buckhorn HMAs. Nonetheless, genetic analysis suggests that there has been a degree of movement into and out of Carter Reservoir HMA, based on estimated numbers of immigrants to and from various HMAs (Cothran et al., 2024).

Determination of Excess Animals
Based on all information available at this time, the BLM has determined that excess wild horses exist within and outside the HMAs and need to be removed. BLM would continue to monitor resources and the wild horses and conduct assessments to help inform management decisions. The following factors for determining excess include, but are not limited to the following:

- In April and May of 2022 (most current completed flight inventories), the BLM conducted an aerial survey of the HMAs and counted 724 wild horses, with Carter Reservoir HMA having 424, Buckhorn HMA having 216, and Coppersmith HMA having 84 (Table 1-3). No burros were counted on the census flight. There are at minimum 529 horses in excess of the AML upper limit (and 590 horses in excess of the AML lower limit).

- Wild horses are using more than 2.5 times their allocated forage based on AUMs allocated by the upper limit AML (Table 1-5).

- Riparian functional assessments completed between 2011 and 2021 document severe utilization of forage within riparian and wetland habitats and extensive trampling and trailing damage by wild horses.

- Cultural resource inventories completed between 2011 and 2021 indicate that wild horse overpopulation is and has contributed to heavy trampling damage of archaeological sites, features, and artifacts resulting in adverse effects to historic properties.\

- Riparian functional assessments completed between 2011 and 2021 document severe over utilization of forage within riparian and wetland habitats.

- Concentrated and extensive year-round trampling in, and immediately around water sources (both fenced and unfenced) by excess wild horses, is responsible for the loss of a thriving ecological balance both on and off the herd management area.

Overall, the 2022 population of horses of each HMA exceeds the total forage allocation for wild horses per HMA (Table 1-5), and the 2024 herd sizes are estimated to be larger than those present in 2022.

Table 1-5. Appropriate Management Levels (AMLs) for the Herd Management Areas (HMAs).

HMA	2022 Population Counts of Horses Both On & Off HMA[2] (Burros Not Listed)	Horses AML	Allocated Forage Based on AML Range for Wild Horses	Current Wild Horse Use by AUM/Year
Carter Reservoir	424	25–35	300 – 420	5,088 203% over Low AUM
Buckhorn	216	59-85	708 – 1,020	2,592 44% over Low AUM
Coppersmith	84	50-75	600 - 900	1,008 20% over Low AUM
Total	724	134 – 195	1608 - 2340	8,688 267% Over AUM Use

[1] Animal Unit Month (AUM) is defined as the amount of forage necessary for the sustenance of one cow or its equivalent for a period of 1 month. Horse AUMS are calculated using one mature horse (with foal) as 1 animal unit equivalent, for a 12-month grazing period.

[2] Reflects results from statistical analysis completed by BLM internal statistician.

*Included in total count for Carter Reservoir. Zero horses counted outside Buckhorn and Coppersmith HMA's.

1.2 Purpose and Need for Action

The purpose of the Proposed Action and other action alternatives is to restore and maintain a thriving natural ecological balance by maintaining wild horse populations within the established AML ranges for the HMAs and to reduce wild horse population growth rates to extend the time between gather events. These actions would allow the BLM to achieve management goals and objectives of attaining and maintaining wild horse and burro populations within AML range, slow the current population growth rate through use of population growth suppression methods, and restore and maintain a thriving natural ecological balance within the HMAs.

These actions are needed to protect rangeland resources from undue or unnecessary degradation, allow for recovery of degraded range resources, and restore a thriving natural ecological balance within a multiple-use relationship on BLM-administered lands in the area consistent with the Federal Land Policy and Management Act of 1976, as amended, the provisions of Section 3(b)(2) of the Wild Free-Roaming Horses and Burros Act of 1971, as amended (Wild Horse and Burro Act),[1] and to manage wild horses within AML in a manner that assures rangeland health standards for upland vegetation and riparian plant communities, watershed function, and habitat quality for wildlife populations are achieved or, if not achieved, that significant progress is made toward achieving them, and which would meet objectives to protect and manage threatened, endangered, and sensitive species.

[1] The Interior Board of Land Appeals (IBLA) defined the goal for managing wild horse (or burro) populations in a thriving natural ecological balance as follows: "As the court stated in Dahl vs. Clark, supra at 594, the 'benchmark test' for determining the suitable number of wild horses on the public range is 'thriving natural ecological balance.' In the words of the conference committee which adopted this standard: 'The goal of WH&B management should be to maintain a thriving ecological balance (TNEB) between WH&B populations, wildlife, livestock and vegetation, and to protect the range from the deterioration associated with overpopulation of wild horses and burros.'"

1.3 Land Use Plan Conformance

The Proposed Action and action alternatives are in conformance with the 2008 Surprise Field Office Resource Management Plan and Record of Decision (BLM, 2008a), Section 2.21.5, and the Nevada and Northeastern California Greater Sage-Grouse Approved Resource Management Plan Amendment (BLM, 2015; ARMPA) and Record of Decision (2015), Section 2.2.5. These documents are available on the National NEPA Register at: E-Planning | Bureau of Land Management (blm.gov)

1.4 Relationship to Laws, Regulations, and Other Plans

The action alternatives are in conformance with the Wild Free-Roaming Horses and Burros Act of 1971 (as amended), applicable regulations at 43 CFR § 4700, and BLM policies (see Appendix B).

1.5 Conformance with Rangeland Health Standards and Guidelines

The BLM completed 34 individual riparian functional assessments within the HMAs between 2018 and 2023 and determined that high amounts of grazing and trampling, resulting from the excess numbers of wild horses in the HMAs, are contributing factors for sites not achieving the Riparian/Wetland Standard for Rangeland Health. See Section 3.3.4 for a complete description of upland and riparian/wetland health assessments and results.

1.6 Decision to be Made

The authorized officer would decide which, if any, actions analyzed in the alternatives and described in Section 2 of this EA to implement in order to best meet the purpose and need of this document. The authorized officer's decision may select gather methods, numbers of horses gathered, and fertility control measures and method(s). The authorized officer would also decide what project design features to apply to any selected actions. The authorized officer would determine whether to implement actions to achieve management objectives of maintaining the Carter Reservoir, Buckhorn, and Coppersmith HMA wild horse population within the established AML, protect the range from deterioration resulting from excess wild horse population, and implementing fertility control. The decision would not set or adjust AML, nor would it adjust livestock use, as these were set through previous land use planning and implementation decisions.

1.7 Scoping and Identification of Issues

The BLM interdisciplinary team identified wild horse and burro issues in the Carter Reservoir, Buckhorn, and Coppersmith Wild Horse Gather Plan EA through internal scoping. For this assessment, the BLM also considered issues from the 2021 Surprise Complex Wild Horse and Burro Gather Plan (DOI-BLM-CA-N070-2021-0009-EA) and the Buckhorn, Coopersmith and Carter Reservoir Wild Horse Herd Management Areas Capture and Remove Plan EA (DOI-BLM-CA-N070-2009-011-EA), which are both hereby incorporated by reference. The issues analyzed in this assessment include the following:

1. Impacts to individual wild horses and the herd including:
   - Projected population size and annual growth rate (PopEquus population modeling)
   - Effectiveness of proposed fertility control application (as modeled in PopEquus)
   - Projected effects to measures of genetic diversity.
   - Impacts to animal health and condition.

2. Impacts to vegetation/soils, riparian/wetland, and cultural resources including:
   - Impacts to vegetation/soils and riparian/wetland resources assessed by measures of Proper Functioning Condition (PFC)

3. Impacts to wildlife, migratory birds, and threatened, endangered, and special status species and their habitat including:
   - Displacement, trampling, disturbance, or population decline
   - Competition for forage and water

4. Impacts to private lands and state highway including:
   - Nuisance horses impeding on private land for water and forage due to limited resources within the herd management areas caused by overpopulation.
   - Horses grazing and watering along state highway 299 creating potentially fatal horse vs vehicle accidents, mainly at night.

See Chapter 6 Consultation and Coordination for information regarding Tribal Consultation. During regularly scheduled consultation meetings between the BLM Applegate Field Office and federally recognized tribes whose ancestral territories and/or areas of interest overlap with field office boundaries, Tribes expressed broad support for wild horse gathers generally and expressed concern that wild horse and burro overpopulation was actively resulting in cultural resource degradation.

The public will have opportunities to provide comments in response to this preliminary EA. BLM will revise this preliminary EA, as appropriate, based on comments received.

2.0 Description of the Alternatives

2.1 Introduction

This section describes the Proposed Action and alternatives, including any that were considered but eliminated from detailed analysis. In this EA, four alternatives are analyzed in detail.

2.2 Description of Alternatives Considered in Detail

The action alternatives were developed in response to the identified resource issues and the purpose and need, as described above.

2.2.1 Management Actions Common to Alternatives 1, 2, and 3

- Gathers would be scheduled by the BLM National Wild Horse and Burro (WH&B) Program Office. Late summer or fall gathers are preferred to avoid seasonal greater sage-grouse restrictions, peak foaling season, and hunting season. Several factors such as animal condition, herd health, weather conditions, or other considerations could result in adjustments in the schedule. The frequency and magnitude of the gathers depends on the number of animals approved for removal following coordination with the National WH&B Program, which must consider space capacity limitations in order to safely hold and care for removed animals. Those considerations could limit the number of gathers that can be conducted annually at the national level.
- Aerial surveys would be used to estimate population size. Distribution flights may occur prior to gathering to determine herd locations but are dependent on BLM National WH&B Program Office priorities and funding.
- Gather operations would be conducted in accordance with the Comprehensive Animal Welfare Program (BLM, 2021). The primary gather capture methods for removal and fertility control, would be the helicopter drive trapping method with occasional helicopter assisted roping (from horseback). Bait and water trapping may also be used to capture animals for removal and fertility control treatment. Gather methods would be determined on a case-by-case basis.
- Darting of animals to apply fertility control for the use of population management may be implemented, preferably once a herd area has reached low AML or is within AML levels. Once this is achieved, a darting program may be implemented with goal of slowing the growth rate of each herd.
- Trap sites and temporary holding facilities would be located in previously used sites or other disturbed areas whenever possible (Appendix D). Undisturbed areas identified as potential trap sites or holding facilities would be inventoried for cultural, botanical, and wildlife resources prior to initiation of gathers. If any special natural or cultural resources are encountered, these locations would not be used unless

they could be modified to avoid impacts to cultural resources, as determined by the field office archaeologist.
- A U.S. Department of Agriculture – Animal and Plant Inspection Service or other veterinarian may be on-site during the gather, as needed, to examine animals and make recommendations to the BLM for care and treatment of captured wild horses.
- Decisions to humanely euthanize animals in field situations would be made in conformance with BLM policy (Permanent Instruction Memorandum [PIM] 2021-007 https://www.blm.gov/policy/pim-2021-007).
- Data such as sex and age distribution of gathered animals, body condition class information (using the Henneke Body Condition Scoring System), color, size, and other information may also be recorded, along with the disposition of that animal (removed or released).
- Wild horse genetic diversity would be monitored as outlined in the BLM wild horse and burro management handbook. If wild horse population size at Carter Reservoir HMA is brought to levels that are at or close to AML, fecal DNA sampling (King et al., 2021) may also be used to increase the frequency of genetic diversity sampling in the absence of a gather, if needed.
- If observed heterozygosity levels are unacceptably low in any of the three HMAs, 3-5 fertile wild horses from outside HMAs would be introduced to that HMA at least every 8-10 years, to augment genetic diversity and reduce the risk of negative effects that could result from inbreeding depression.
    - For Carter Reservoir HMA, introduced horses would preferentially be drawn from other wild horse herds with similar color and conformation such as Sulphur HMA, Kiger HMA, or other herds with a relatively high prevalence of the *dun* factor.
- The movements and foaling status of mares that are returned to the range may be monitored by means of safe and humane GPS radio collars that have redundant drop-off mechanisms (Appendix N).
- Excess animals that are removed would be transported to BLM off-range corrals where they would be prepared (e.g., freeze-marked, micro-chipped, vaccinated, de-wormed, and gelded) for adoption, sale (with limitations), or for transport to off-range pastures, in accordance with current policy.
- Animals transported to a BLM off-range corral are inspected by facility staff and the BLM contract veterinarian to observe health and ensure the animals have been cared for humanely, and to monitor for health conditions including contagious pathogens.
- There is no burro AML for any of the HMAs, therefore any burros gathered from within or outside the HMAs would be removed.
- No trap sites would be set up within a four-mile buffer of active and/or pending greater sage-grouse leks during the lekking and nesting seasons in areas of documented use determined by telemetry locations. Areas within a four-mile buffer of active and/or pending leks would be considered avoidance areas and protect approximately 85% of nesting greater sage-grouse.
    - BLM may consult with Nevada Department of Wildlife (NDOW) to determine if temporary trap site use would have an impact to sage grouse, including whether it would be more beneficial to sage grouse habitat for BLM to remove the horses within the four-mile buffer.
- No trap sites would be set up in proximity to known populations of other sensitive wildlife species.
- All animals gathered from outside of established HMA boundaries would be removed. No horses would be returned to areas outside the HMAs.

The BLM Contracting Officer’s Representative (COR) and Project Inspectors (PIs) assigned to any gather would be responsible for ensuring contract personnel abide by the gather-related standards for the Comprehensive Animal Welfare Policy (CAWP; BLM, 2021). Ongoing monitoring of forage condition and utilization, water availability, aerial population surveys, and animal health would continue.

Fertility control monitoring would be conducted in accordance with the 2010 WHB handbook. Genetic diversity monitoring would take place, consistent with the BLM wild horse and burro management handbook (BLM, 2010). Monitoring the herds’ social behavior would opportunistically be incorporated into routine monitoring. One topic of interest for behavioral monitoring could be to determine if additional studs form bachelor bands or are more aggressive with breeding bands for the forage and water present.

Required Design Features (RDF)
The following RDFs would be applied to be consistent with the GRSG ARMPA:

1. RDF Gen 12: Control the spread and effects of nonnative, invasive plant species (e.g., by washing vehicles and equipment, minimize unnecessary surface disturbance). All projects would be required to have a noxious weed management plan in place prior to construction and operations.
2. RDF Gen 13: Implement project site-cleaning practices to preclude the accumulation of debris, solid waste, putrescible wastes, and other potential anthropogenic subsidies for predators of greater sage-grouse.
3. RDF Gen 17: Restore disturbed areas at final reclamation to the pre-disturbance landforms and desired plant community.
4. RDF Gen 19: Instruct all construction employees to avoid harassment and disturbance of wildlife, especially during the greater sage-grouse breeding (e.g., courtship and nesting) season. In addition, pets shall not be permitted on site during construction.
5. RDF Gen 22: Load and unload all equipment on existing roads, pull outs, or disturbed areas to minimize disturbance to vegetation and soil.

2.2.2 Management Actions Common to Alternatives 1 and 2

- Mares released back to the HMAs would be treated with fertility control methods such as Porcine Zona Pellucida (PZP) vaccine, GonaCon-Equine vaccine, or a similar approved immunocontraceptive vaccine and/ or an intrauterine device (IUD). Fertility control treatment would be conducted in accordance with approved standard operating and post-treatment monitoring procedures (SOPs, Appendix E). Mares returned to the range would be selected to maintain a diverse age structure, herd characteristics, and conformation.
- Post-gather, every effort would be made to return released horses to the same general area within individual HMAs from which they were gathered.

2.2.3 Alternative 1 (Proposed Action): Gather and Removal of Excess Wild Horses to Low-AML, Population Growth Suppression, and Sex Ratio Adjustment

The Proposed Action has three separate goals to be accomplished in the following order:

1. Immediately gather and remove excess animals to reach low AML as expeditiously as feasible through an initial gather, and if necessary, a follow-up gather(s). Follow-up gathers to remove excess animals to achieve low AML shall be conducted as promptly as appropriate to allow sufficient time for the animals to settle after a helicopter gather and to provide for a safe, efficient, and effective follow-up gather operation.[2]
2. Treatment of mares to be returned to the HMAs with fertility control methods potentially including immunocontraceptive vaccines or flexible intrauterine devices (IUDs).
3. Sex ratio adjustment to 60% males and 40% females.

Prior to conducting a follow-up gather or gathers if needed to achieve low AML for the HMAs, BLM would review the most current population estimates, monitoring data, and determine whether there are any new circumstances or information that would substantially change the prior analysis to determine whether further environmental analysis or a new decision is necessary.

[2] While the BLM's plan would be to immediately remove all excess animals above low AML and include enough mare fertility control treatments to slow population growth, it is possible that a single gather would not achieve this because of limitations such as on gather efficiency, logistics, space capacity for holding removed animals, or contractor availability. The result would be a need to conduct a follow-up gather or gathers to achieve low AML.

Gather and Remove

The Proposed Action would gather and remove as many excess wild horses and burros as feasible (based on gather efficiencies and holding capacity) from within and outside the HMAs in an initial gather to achieve low AML and if the AML range is not reached with the initial gather, would conduct follow-up gathers after the initial gather until low AML is reached. While the Proposed Action is to promptly remove all remaining excess animals above low AML, BLM's experience reveals that it is unlikely that a single gather can achieve this objective because of gather efficiency limitations (e.g., animals evading capture during the gather operations), logistical limitations (e.g. weather conditions, terrain and large geographic area to be gathered), space capacity limitations (for safely holding and caring for removed animals) that limit the number of gathers that can be conducted annually at the national level, and limited availability of contractors with the experience necessary to safely and humanely capture wild horses. As a result, it often requires more than a single gather to bring the population to low AML, if only to capture animals that would have been removed if they had not evaded capture during the gather, or because a gather was ended early due to inclement weather conditions. BLM's management to achieve a thriving natural ecological balance is also not limited to removing excess animals, but also includes measures to reduce annual population growth and to allow for recovery of degraded vegetation and riparian areas impacted by the wild horse and burro over population—which requires a sufficient period of active management to achieve these objectives.

If the initial gather does not result in the population reaching low AML, prior to conducting a follow-up gather to remove the remaining excess animals, BLM would review data on the most recent population estimates and new monitoring data to determine whether a follow-up gather is still needed and whether the remaining excess animals can be removed through targeted trapping operations or whether a helicopter gather is necessary. BLM would also consider whether there are any significant new circumstances or information that require further NEPA analysis and additional process, or whether the follow-up gather to achieve AML objectives can proceed under this Proposed Action. Therefore, multiple gathers could occur to achieve low AML and would be needed to achieve management objectives for the Proposed Action. After each gather, an aerial survey would be completed, as funding allows, to count the remaining population and determine whether there are still excess animals.

Fertility Control

The BLM has identified fertility control as a method of population growth reduction that could be used to protect rangeland ecosystem health, maintain the population within AML for a longer period of time, and reduce the frequency of wild horse and burro gathers and removals of excess animals. For more information on fertility control methods and possible effects, see Appendix N. Expanding the use of population growth suppression to slow population growth rates and reduce the number of animals removed from the range and sent to off-range pastures is a BLM priority. Contraception has been shown to be a cost-effective and humane treatment to slow increases in wild horse populations or, when used with other techniques, to reduce horse population size (Bartholow, 2004; de Seve & Boyles-Griffin, 2013; Fonner & Bohara, 2017). No finding of excess animals is required for the BLM to pursue contraception in wild horses or burros.

Under this alternative, the BLM would attempt to gather a sufficient number of wild horses during its immediate gather and removal operations to allow for the application of fertility control vaccines (PZP ZonaStat-H, PZP-22, GonaCon, or other approved formulation) and/ or IUDs to all mares that are released, such that the population growth rates are reduced to a rate below approximately 5% per year. The BLM may also later administer fertility control treatments and/or boosters to control the wild horse population and keep it within AML. The BLM could administer those treatments by gathering, treating, and releasing treated animals or through other methods like darting.

Consistent with the Purpose and Need, the BLM intends for each of the herds in these HMAs to continue reproducing, but at levels that allow for management within AML and a prolonged time period between gathers after AML has been reached. Fertility control implementation would follow current program policy and guidelines (BLM, 2010). Unless the herd is already growing at desirably low levels (for example, below 5% per year), gathers for population control would result in mares captured and selected for release to be treated or have a booster with fertility control treatments such as GonaCon-Equine, PZP-22, ZonaStat-H (native PZP), or most current approved vaccine formulations to prevent pregnancy in the following year(s).

It is generally thought that, to prevent a wild horse herd from growing, 60%-90% of all mares must be infertile every year (Grams et al., 2022). That fraction of infertile mares, which has also been called the 'fertility control index,' would be approximated via monitoring activities including aerial surveys and ground-based observations conducted during the course of management. In the Coppersmith and Buckhorn HMAs it is not likely that BLM would ever gather all horses present, and it is also likely that mares from the neighboring Twin Peaks HMA may move onto Coppersmith and Buckhorn HMAs, so even with fertility control applications for mares released back to those two HMAs, it is expected that a relatively large fraction of mares (e.g., 50% or more) would be fertile there at any given time period.

All animals treated with any type of fertility control would be freeze marked/microchipped and identified according to current policy. Some females could be treated once at the temporary holding facility and released back into the HMA, while other females could be removed to the off-range corrals for treatment prior to release back to the HMAs.

For the ZonaStat-H form of PZP vaccine, annual retreatments are necessary to maintain fertility control efficacy, except that after a mare has received approximately 5 treatments over a prolonged time period that mare is expected to remain infertile for many years (Appendix N). Because ZonaStat-H treated mares return to fertility at a relatively fast rate, this vaccine would likely be the main initial choice of fertility control treatment at Carter Reservoir, because allowing for a range of mares to foal in that HMA (along with periodically introducing appropriate, fertile animals from other HMAs) should help to reduce the rate of genetic diversity loss due to genetic drift even when that herd is at AML.

In contrast, long-term infertility can be expected for mares that are treated by two or three doses of GonaCon-Equine vaccine if those doses are separated by months or years (Appendix N). Because of the potentially longer-lasting effects, GonaCon-Equine vaccine would likely be the main initial choice of fertility control treatment at Coppersmith HM and Buckhorn HMA, where it is less likely that the BLM could logistically achieve a high 'i control index' in the immediate future. For any given year when gather or fertility control activities are possible, decisions about the number and type of fertility control treatments for mares would be made based on current monitoring data related to herd size and foal to adult ratios, availability of treatments, space at off-range corrals, and mares with foals would be less likely to be released. Fertility control vaccine treatments and re-treatments could be administered as part of capture and release operations, in off-range corrals, or by remote delivery (e.g., darting). IUD treatments require animal handling and can only be used for mares that are not pregnant (Appendix E).

Liquid emulsion vaccines can be injected by hand or remotely administered in the field using a pneumatic dart (Roelle & Ransom, 2009; Rutberg et al., 2017; McCann et al., 2017) in cases where mares are relatively approachable and reliably identifiable at the individual level. Use of remotely delivered (dart-delivered) vaccine is generally limited to populations where individual animals can be accurately identified and repeatedly approached within 50 meters (BLM, 2010; Rutberg et al., 2017). Darting can be implemented opportunistically by applicators near water sources or along main trails out on the range. Blinds may be used to camouflage applicators to allow efficient treatment of as many mares as possible. ZonaStat-H, GonaCon-Equine (or other effective vaccine formulations) would be administered by applicators field darting the mares. PZP-22 pellets have also been delivered via darting in trial studies (Rutberg et al., 2017; Carey et al., 2019), and this could be included as a method in these HMAs (Appendix E). Prior to darting, an inventory of the wild horses would be conducted. This could include a list of marked horses and/or a photo catalog with descriptions of the animals to assist in identifying which animals have been treated and which need to be treated.

Intrauterine Devices (IUDs)

Based on promising results from studies in domestic mares, BLM has begun to use IUDs to control fertility as a wild horse and burro fertility control method on the range. The initial management use was in mares from the Swasey HMA, in Utah. The BLM has supported and continues to support research into the development and testing of effective and safe IUDs for use in wild horse mares (Baldrighi et al., 2017; Holyoak et al., 2021). However, existing literature on the use of IUDs in horses allows for inferences about expected effects of any management alternatives that might include use of IUDs and support the apparent safety and efficacy of some types of IUDs for use in horses (Appendix N). Overall, as with other methods of population growth suppression, use of IUDs and other fertility control measures are expected to help reduce population growth rates, extend the time interval between gathers, and reduce the total number of excess animals that would need to be removed from the range.

The 2013 National Academies of Sciences report considered IUDs and suggested that research should test whether IUDs cause uterine inflammation and should also test how well IUDs stay in mares that live and breed with fertile stallions. Since that report, a recent study by Holyoak et al., (2021) indicate that a flexible, inert, y-shaped, medical-grade silicone IUD design prevented pregnancies in all the domestic mares that retained the device, even when exposed to fertile stallions. Domestic mares in that study lived in large pastures, mating with fertile stallions. Biweekly ultrasound examinations showed that IUDs stayed in 75% of treated mares over the course of two breeding seasons. The IUDs were then removed so the researchers could monitor the mares' return to fertility. Uterine health, as measured in terms of inflammation, was not seriously affected by the IUDs, and most mares became pregnant within months after IUD removal. The overall results are consistent with results from an earlier study (Daels & Hughes, 1995), which used O-shaped silicone IUDs.

IUDs are considered a temporary fertility control method that does not generally cause future sterility (Daels & Hughes, 1995). Use of IUDs is an effective fertility control method in women, and IUDs have historically been used in livestock management, including in domestic horses. Insertion of an IUD can be a very rapid procedure, but it does require the mare to be temporarily restrained, such as in a squeeze chute. IUDs in mares may cause physiological effects including discomfort, infection endometritis, uterine edema, perforation of the uterus if the IUD is hard and angular (Killian et al., 2008), and pyometra (Klabnik-Bradford et al., 2013). In women, deaths attributable to IUD use may be as low as 1.06 per million (Daels & Hughes, 1995).

The exact mechanism by which IUDs prevent pregnancy is uncertain (Daels & Hughes, 1995), but the presence of an IUD in the uterus may, like a pregnancy, prevent the mare from coming back into estrus (Turner et al., 2015). However, some domestic mares did exhibit repeated estrus cycles during the time when they had IUDs (Killian et al., 2008; Gradil et al., 2019). The main cause for an IUD to not be effective at contraception is its failure to stay in the uterus (Daels & Hughes, 1995). As a result, one of the major challenges to using IUDs to control fertility in mares on the range is preventing the IUD from being dislodged or otherwise ejected over the course of daily activities, which could include, at times, frequent breeding.

At this time, it is thought that any IUD inserted into a pregnant mare may cause the pregnancy to terminate, which may also cause the IUD to be expelled. For that reason, it is expected that IUDs would only be inserted in non-pregnant (open) mares (Appendix E). Wild mares receiving IUDs would be checked by a veterinarian for pregnancy prior to insertion of an IUD. This can be accomplished by transrectal palpation and/or ultrasound performed by a veterinarian. Pregnant mares would not receive an IUD. The IUD is inserted into the uterus using a thin, tubular applicator similar to a shielded culture tube, and would be inserted in a manner similar to that routinely used to obtain uterine cultures in domestic mares. If a mare has a zygote or very small, early phase embryo, it is possible that it would fail to be detected in screening, and may develop further, but without causing the expulsion of the IUD. Wild mares with IUDs would be individually marked and identified, so that they can be monitored occasionally and examined, if necessary, in the future, consistent with other BLM management activities.

Using metallic or glass marbles as IUDs may prevent pregnancy in horses (Nie et al., 2003), but can pose health risks to domestic mares (Turner et al., 2015; Freeman & Lyle, 2015). Marbles may break into shards (Turner et al., 2015), and uterine irritation that results from marble IUDs may cause chronic, intermittent colic (Freeman & Lyle, 2015). Metallic IUDs may cause severe infection (Klabnik-Bradford et al., 2013).

In domestic ponies, Killian et al. (2008) explored the use of three different IUD configurations, including a silastic polymer O-ring with copper clamps, and the "380 Copper T" and "GyneFix" IUDs designed for women. The longest retention time for the three IUD models was seen in the "T" device, which stayed in the uterus of several mares for 3-5 years. Reported contraception rates for IUD-treated mares were 80%, 29%, 14%, and 0% in years 1-4, respectively. They surmised that pregnancy resulted after IUD fell out of the uterus. Killian et al. (2008) reported high levels of progesterone in non-pregnant, IUD-treated ponies.

Soft IUDs may cause relatively less discomfort than hard IUDs (Daels & Hughes, 1995). Daels and Hughes (1995) tested the use of a flexible O-ring IUD, made of silastic, surgical-grade polymer, measuring 40 mm in diameter; in five of six breeding domestic mares tested, the IUD was reported to have stayed in the mare for at least 10 months. In mares with IUDs, Daels and Hughes (1995) reported some level of uterine irritation but surmised that the level of irritation was not enough to interfere with a return to fertility after IUD removal.

More recently, several types of IUDs have been tested for use in breeding mares. When researchers attempted to replicate the O-ring study of Daels and Hughes (1995) in an USGS / Oklahoma State University (OSU) study with breeding domestic mares, using various configurations of silicone O-ring IUDs, the IUDs fell out at unacceptably high rates over time scales of less than 2 months (Baldrighi et al., 2017). Subsequently, the USGS / OSU researchers tested a Y-shaped IUD to determine retention rates and assess effects on uterine health. Retention rates were greater than 75% for an 18-month period, and mares returned to good uterine health and reproductive capacity after removal of the IUDs (Holyoak et al., 2021). These Y-shaped silicone IUDs are considered a pesticide device by the Environmental Protection Agency (EPA), in that they work by physical means (EPA, 2020). The University of Massachusetts has developed a magnetic IUD that has been effective at preventing estrus in non-breeding domestic mares (Gradil et al., 2019). After insertion in the uterus, the three subunits of the device are held together by magnetic forces as a flexible triangle. A metal detector can be used to determine whether the device is still present in the mare. In an early trial, two sizes of those magnetic IUDs fell out of breeding domestic mares at high rates (Holyoak et al., 2021). In 2019, the magnetic IUD was used in two trials where mares were exposed to stallions, and in one where mares were artificially inseminated; in all cases, the IUDs were reported to stay in the mares without any pregnancy (Gradil, 2019).

Sex Ratio Manipulation

Sex ratio manipulation, leading to a reduced fraction of mares in the herd, can be considered a form of contraceptive management, insofar as it can reduce the realized growth rate in a herd. By reducing the proportion of breeding females in a population (as a fraction of the total number of animals present), the technique leads to fewer foals being born, relative to the total herd size (see Appendix N). Sex ratio is typically adjusted in such a way that 60% of the horses are male. In the absence of other fertility control treatments, this 60:40 sex ratio can temporarily reduce population growth rates from approximately 20% to approximately 15% (Bartholow, 2004). While such a decrease in growth rate may not appear to be large or long-lasting, the net result can be that fewer foals are born, at least for a few years – which can extend the time between gathers, and reduce impacts on-range, and costs off-range. Any impacts of sex ratio manipulation are expected to be temporary because the sex ratio of wild horse foals at birth is approximately equal between males and females (NRC, 2013), and it is common for female foals to reproduce by their second year (NRC, 2013). Thus, within a few years after a gather and selective removal that leads to more males than females, the sex ratio of reproducing wild horses would be returning toward a 50:50 ratio.

Gathers and Associated Activities

The BLM has been conducting wild horse and burro gathers since the mid-1970s. During this time, methods and procedures have been identified and refined to minimize stress and impacts to wild horses and burros during gather implementation. Published reviews of agency practice during gathers and subsequent holding operations confirm that BLM follows guidelines to minimize those impacts and ensure humane animal care and high standards of welfare (GAO, 2008; AAEP, 2011; Greene et al., 2013; Scasta, 2019). The Comprehensive Animal Welfare Program (CAWP) in Appendix C would be implemented to ensure a safe and humane gather occurs and would minimize potential stress and injury to wild horses and burros.

Transport, Off-Range Corral (ORC) Holding, and Adoption (or Sale) Preparation

Animals would be transported from the capture/temporary holding corrals to the designated BLM off-range corrals ORC(s). From there, they would be made available for adoption or sale to qualified individuals or sent to off-range pastures (ORP).

Wild horses or burros selected for removal from the range would be transported to the receiving ORC in straight deck semi-trailers or goose-neck stock trailers. Vehicles would be inspected by the BLM Contracting Officer's Representative (COR) and Project Inspectors (PIs) prior to use to ensure wild horses and burros can be safely transported and that the interior of the vehicle is in sanitary condition. Wild horses and burros would be segregated by age and sex and loaded into separate compartments. A small number of mares or jennies may be shipped with foals. Travel time for recently captured wild horses or burros is limited to a maximum of 10 hours.

Upon arrival at the ORC, recently captured wild horses and burros would be off-loaded by compartment, placed in holding pens, and fed good quality hay and water. Most wild horses and burros would begin to eat and drink immediately and adjust rapidly to their new situation. At the ORC, a veterinarian would examine each load of horses and provide recommendations to the BLM regarding care, treatment, and if necessary, euthanasia. Any animals with a chronic or incurable disease, injury, lameness, or serious physical defect (such as severe tooth loss or wear, club feet, and other severe congenital abnormalities) would be humanely euthanized using methods acceptable to the American Veterinary Medical Association (AVMA). Wild horses and burros in very thin condition or animals with injuries would be sorted and placed in hospital pens, fed separately and/or treated for their injuries as indicated. Recently captured animals in very thin condition may have difficulty transitioning to feed. Some of these animals may be in such poor condition that it is unlikely they would have survived if left on the range. Similarly, some females may lose their pregnancies. Certain management techniques would be taken to help females make a quiet, low stress transition to captivity and domestic feed to minimize the risk of miscarriage or death.

After recently captured wild horses and burros have transitioned to their new environment, they would be prepared for adoption or sale. Preparation involves freeze marking the animals with a unique identification number, microchipping, drawing a blood sample to test for equine infectious anemia, vaccination against common diseases, castration, and de-worming.

At ORCs, a minimum of 700 square feet is provided per animal. Mortality at ORCs averages approximately 5% per year (GAO, 2008), and includes animals euthanized due to pre-existing conditions; animals in extremely poor condition; animals that are injured and would not recover; animals which are unable to transition to feed; and animals which are seriously injured or accidentally die during sorting, handling, or preparation.

Adoption or Sale with Limitations and Off-Range Pastures (ORP)
Adoption applicants are required to have at least a 400 square foot corral with panels that are at least six feet tall for horses over 18 months of age. Applicants are required to provide adequate shelter, feed, and water. The BLM retains title to the horse for one year and the horse and the facilities are inspected to assure the adopter is complying with the BLM's requirements. After one year, the adopter may take title to the horse, at which point the horse becomes the property of the adopter. Adoptions are conducted in accordance with 43 CFR 4750.

Potential buyers must fill out an application and be pre-approved before they may buy a wild horse. A sale-eligible wild horse is any animal that is more than 10 years old or has been offered unsuccessfully for adoption three times. The application also specifies that buyers cannot re-sell the animal to slaughter buyers or anyone who would sell the animal to a commercial processing plant. Sales of wild horses are conducted in accordance with BLM policy.

ORPs are designed to provide excess wild horses with humane, life-long care in a natural setting off the public rangelands. Wild horses are maintained in grassland pastures large enough to allow free-roaming behavior and with the forage, water, and shelter necessary to sustain them in good condition. About 37,000 wild horses that are in excess of the existing adoption or sale demand (because of age or other factors) are currently located on private land pastures in Iowa, Kansas, Oklahoma, Missouri, Montana, Nebraska, Wyoming, Utah, and South Dakota. Located mainly in mid or tall grass prairie regions of the United States, these ORP are typically highly productive grasslands as compared to more arid western rangelands. These pastures comprise about approximately 400,000 acres. The majority of these animals are older in age.

Euthanasia and Sale without Limitation
Under the Wild Horse and Burro Act, healthy excess wild horses or burros should be humanely euthanized or sold without limitation if there is no adoption demand for the animals. However, while euthanasia and sale without limitation are allowed under the statute, for several decades Congress has prohibited the use of appropriated funds for this purpose. If Congress were to lift the current appropriations restrictions, then it is possible that excess horses removed from the HMAs could potentially be euthanized or sold without limitation consistent with the provisions of the Wild Horse and Burro Act.

Any old, sick, or lame horses unable to maintain an acceptable body condition (greater than or equal to a Henneke BCS of 3) or with serious physical defects would be humanely euthanized either before gather activities begin or during the gather operations as well as at off-range holding facilities in accordance with PIM 2021-007.

2.2.4 Alternative 2: Gather and Removal of Excess Wild Horses to Low AML and Population Growth Suppression
Alternative 2 is similar to Alternative 1 but would not include a sex ratio adjustment. As with Alternative 1, excess wild horses inside and outside the HMAs would be gathered to low AML immediately through an initial gather and follow-up gather(s) as needed. Alternative 2 would also include the removal of any burros, population growth control using fertility control vaccine treatments for mares (PZP, PZP-22, GonaCon, or most current approved formula) and/or IUDs. Under Alternative 2, the BLM would gather and remove excess wild horses and burros within the project area to return the population levels to low AML range. All excess wild horses and burros residing in areas outside of the HMAs would be gathered and removed. Under this alternative, the BLM would attempt to gather a sufficient number of wild horses to also allow for the application of fertility control (PZP, PZP-22, GonaCon, or other approved formulation) and/or IUDs to all mares that are released. The procedures to be followed for implementation of fertility control are detailed in

Appendix E. The BLM may also administer fertility control treatments and/or boosters to help keep the population at AML.

See Alternative 1 (Section 2.2.3) for descriptions on fertility control vaccines that also pertain to Alternative 2.

See Alternative 1 (Section 2.2.3) for descriptions regarding gathers, transport, off-range corral (ORC) holding, and adoption (or sale) preparation, adoption or sale with limitations and off-range pastures (ORP), euthanasia and (prohibited) sale without limitation, all of which pertain to Alternative 2.

2.2.5 Alternative 3: Gather and Removal Only

Alternative 3 would limit management activities to gathering and removing excess wild horses and burros from within and outside the HMAs in an initial gather and any necessary follow-up gather(s) until low AML has been reached. Under this alternative, fertility control methods would not be applied and no changes to the herd's existing sex ratio would be made.

See Alternative 1 (Section 2.2.3) for descriptions regarding gathers, transport, off-range corral (ORC) holding, and adoption (or sale) preparation, adoption or sale with limitations and off-range pastures (ORP), euthanasia and (prohibited) sale without limitation all of which pertain to Alternative 3.

2.2.6 Alternative 4: No Action

Under Alternative 4, no gather, removal, and no population management to control the size of the wild horse population within the HMAs would occur. The No Action Alternative would not achieve the identified purpose and need. However, it is analyzed in this EA to provide a basis for comparison with the other action alternatives and to assess the effects of not conducting any gathers, removals, or fertility control. The No Action Alternative would violate the Wild Horse and Burro Act, which requires the BLM to gather information, determine if an overpopulation exists and excess animals need to be removed, prioritize and immediately remove such excess animals from the range until all excess animals have been removed to restore a thriving natural ecological balance to the range and protect further rangeland deterioration due to overpopulation of animals. The analysis assumes that normal population growth cycles would occur.

2.3 Alternatives Considered but Dismissed from Detailed Analysis

1. **Exclusive Use of Bait and/or Water Trapping**

This alternative involves the use of bait (feed) and/or water to lure horses and burros into trap sites as the primary gather method. It would not be timely, cost-effective, or practical to use bait and/or water trapping as the only gather method because the number of water sources on both private and public lands within and outside the HMAs would make it almost impossible to restrict wild horse and burro access to the selected water trap sites. Bait and/or water trapping may be used in strategic locations to assist in removals and fertility control treatments. Scasta (2019), found mortality ratios did not differ by capture technique ($P>0.05$ for broken necks, emaciation, acute causes, or chronic/pre-existing conditions and noted capture mortality rates across all gathers sampled at 1.1% which is below a general threshold of 2% that Scasta (2019) suggested was a goal for wildlife studies. As a result, this alternative was dismissed from detailed analysis due to it being ineffective for reducing further damage to resources in a reasonable time frame.

2. **Remove or Reduce Livestock within the HMAs**

This alternative would involve no removal of wild horses and burros in the HMAs and would instead remove or reduce authorized livestock grazing. This alternative was not considered in detail because it is contrary to previous decisions which allocated forage for livestock use and would not be in conformance with the existing land use plan nor does it achieve the purpose and need for this EA. Livestock grazing can only be reduced or eliminated through provisions identified within regulations (43 CFR 4100) and must be consistent with multiple use allocation set forth in the RMP. This alternative would exchange use by livestock for use by wild horses through the elimination or reduction of grazing in order to shift forage use to wild horses, which would not be in conformance with the Surprise RMP. Additionally, it is contrary to the BLM's multiple-use mission as outlined in the 1976 Federal Land Policy and Management Act. The BLM is required to manage wild horses and burros in a manner designed to achieve a thriving natural ecological balance between wild horse and burro populations, wildlife, livestock, and other uses. Wild horses have been identified as a causal factor in not meeting rangeland health standards. Thus, reducing livestock AUMs to increase AMLs would not achieve a thriving natural ecological balance. Horses are present year-round and their impacts to rangeland resources differ from livestock, as livestock can be controlled through an established grazing system (confinement to specific pastures and limited period or season of use to minimize impacts to vegetation and riparian). This alternative would also be inconsistent with the Wild Horse and Burro Act, which directs the immediate removal of excess wild horses and burros and requires management for a thriving natural ecological balance. As a result, this alternative was dismissed from detailed analysis due to it being inconsistent with the Land Use Plan (i.e., Surprise RMP).

3. Gather the HMAs to the AML Mid or Upper Limit

Under this alternative, a gather would be conducted to remove enough wild horses to achieve the mid or upper range of the AML. This alternative was dismissed from detailed study because AML would be exceeded by the next foaling season following a gather resulting in the need to conduct another gather within one year. This would result in increased stress to individual wild horses and the herd. Resource damage due to wild horse overpopulation would continue in the interim, as the mid and upper levels of the AML established for the HMAs represents the near maximum or maximum population for which thriving natural ecological balance would be maintained. As a result, this alternative was dismissed from detailed analysis due to it being substantially similar to the Proposed Action.

4. Fertility Control Treatment Only (No Removal)

Under this alternative, no excess wild horses and burros would be removed. Population modeling (which does not apply to burros) analyzed the potential impacts associated with conducting gathers about every 2 to 3 years over the next 20-year period to treat captured mares with fertility control. Due to the vast size of these HMAs, wide distribution of animals, and inaccessibility to the animals, remote darting opportunities are extremely limited because of the annual retreatment requirements to maintain vaccination efficiency. While there would be an average reduction of 15.9% to 24.7%, compared to the current annual population growth rate (as modeled in PopEquus), AML would still not be achieved through fertility control alone and damage to the range associated with wild horse and burro overpopulation would continue. Moreover, this alternative would not meet the Purpose and Need for the Action and would be contrary to the Wild Horse and Burro Act.

5. Designate the HMAs to be Managed Principally for Wild Horse or Burro Herds

This alternative would address the issue of excess wild horses in the HMAs through the complete removal of authorized livestock grazing, instead of by gathering and/or removing excess wild horses and burros from the HMA. This alternative would be contrary to the 2008 Surprise RMP by allowing the wild horse and burro population to remain above AML. Therefore, this alternative does not meet the purpose and need to achieve and maintain the established AMLs.

This alternative is also inconsistent with the Wild Horse and Burro Act, which directs the Secretary to immediately remove excess wild horses and burros when a determination is made that such a removal is necessary to achieve a thriving natural ecological balance. The current apportionment of multiple use grazing between livestock and wild horses and burros was established through a lengthy public review process between 2004 and 2008, and the result of that decision-making process is set forth in the approved Surprise RMP. The available monitoring data does not indicate a need to change the level of livestock grazing. Nor does the available monitoring data indicate that changes to AML are warranted at this time, since there is no evidence of changes in habitat conditions (such as greater availability of water) that would allow for increases in the wild horse AML.

The current population of wild horses above AML is resulting in adverse impacts to water sources, riparian/wetland sites, and vegetation. Even in areas where there has been little to no livestock grazing, monitoring data indicates that wild horse impacts are affecting the BLM's ability to manage for rangeland health.

The current level of authorized livestock grazing has been established through inventory and monitoring data over the past 50 years. Forage allocations for livestock have been made in accordance with forage and habitat needs for wildlife and wild horses and burros. The BLM has not received any new information that would indicate a need to change the level of livestock grazing at this time. Furthermore, the BLM establishes grazing systems to manage livestock grazing through specific terms and conditions that confine grazing to specific pastures, limit periods of use, and set utilization standards. These terms and conditions minimize livestock grazing impacts to vegetation during the growing season and to riparian zones during the summer months.

Wild horses, however, are present year-round, and their impacts to rangeland resources cannot be controlled through establishment of a grazing system, such as for livestock. Thus, impacts from wild horses can only be addressed by limiting their numbers to a level that does not adversely impact rangeland resources and other multiple uses.

While the BLM is authorized to remove livestock from HMAs "if necessary to provide habitat for wild horses or burros, to implement herd management actions, or to protect wild horses or burros from disease, harassment or injury" (43 CFR § 4710.5), this authority is usually applied in cases of specific emergency conditions and not for the general management of wild horses or burros under the Wild Horse and Burro Act, as wild horse and burro management is based on the land-use planning process, multiple use decisions, and establishment of AML. For these reasons, this alternative was eliminated from further consideration.

6. Raising the Appropriate Management Level

The BLM has established current AML ranges based on many years of data collection, resource monitoring, and multi-agency planning efforts. The current AMLs are based on established biological resource monitoring protocols and land health assessments and were approved in the 2008 Surprise RMP. Delay of a gather until the AML can be reevaluated is not consistent with the Wild Horse and Burro Act, Public Rangelands Improvement Act, FLPMA, or the 2008 Surprise RMP. Monitoring data collected within the HMAs does not indicate that an increase in AML is warranted at this time. On the contrary, such monitoring data confirms the need to remove excess wild horses to reverse downward resource trends and promote improvement of rangeland and riparian health. Severe resource degradation would occur in the meantime and large numbers of excess animals would ultimately need to be removed from the HMAs in order to achieve AML or to prevent the death of individual animals under emergency conditions. This alternative was eliminated from further consideration because it is contrary to the Wild Horse and Burro Act, which requires the BLM to manage the rangelands to prevent resources from deterioration associated with an overpopulation of wild horses and burros. In addition, raising the AML where there are known resource degradation issues associated with an overpopulation of wild horses does not meet the purpose and need of this EA to restore and maintain a thriving ecological balance. If future data suggest that adjustments in the AML are needed (either upward or downward), then changes would be based on an analysis of monitoring data, including a review of wild horse habitat suitability, such as the condition of water sources in the HMAs. As a result, this alternative was eliminated from further consideration due to it being inconsistent with the basic policy objectives of the Land Use Plan.

7. Control of Wild Horse Population by Natural Means

This alternative was eliminated from further consideration because it is contrary to the Wild Horse and Burro Act, which requires the BLM to prevent range deterioration associated with an overpopulation of wild horses and burros. Reliance on natural controls to achieve a desirable AML has not been shown to be effective as evidenced by population growth in the HMAs. Wild horse and burro populations in the HMAs have not been shown to be controlled by predators or other natural factors. In addition, wild horses are a long-lived species with documented foal survival rates exceeding 95% and they do not self-regulate their population growth rate. A 2013 National Research Council of the National Academies of Sciences report concluded that the primary way that equid populations self-limit is through increased competition for forage at higher densities, which results in smaller quantities of forage available per animal, poorer body condition and decreased birthrate and survival (NRC, 2013). It also concluded that the effect of this would be impacts to resource and herd health that are contrary to BLM management objectives and statutory and regulatory mandates. This alternative would result in a steady increase in the wild horse populations which would continue to exceed the carrying capacity of the range resulting in a catastrophic mortality of wild horses in the three HMAs considered here, and irreparable damage to rangeland resources. Mountain lions are known to predate on horses, primarily foals, in a few herds (Andreasen et al., 2021; Schulman et al., 2024), but predation contributes to biologically meaningful population limitation in only a handful of herds. Andreasen et al. (2021) concluded that “At landscape scales, cougar predation is unlikely to limit the growth of feral horse populations.”

This alternative would result in a steady increase in the wild horse and burro populations which would continue to exceed the carrying capacity of the range until it results in a catastrophic mortality of wild horses in the HMAs. As the vegetative and water resources are degraded to the point of no recovery as a result of the wild horse and burro overpopulation, wild horses would start showing signs of malnutrition and starvation. The weaker animals, generally the older animals, and the mares and foals, would be the first to be impacted. It is likely that a majority of these animals would die from starvation and dehydration which could lead to a catastrophic die off. Allowing horses to die of dehydration and starvation would be inhumane treatment and would be contrary to the Wild Horse and Burro Act, which mandates removal of excess wild horses and humane treatment of the animals.

This alternative would also lead to irreparable damage to rangeland resources from excess wild horses and burros, which is contrary to the Wild Horse and Burro Act, which mandates the BLM to *“protect the range from the deterioration associated with overpopulation”, “remove excess animals from the range so as to achieve appropriate management levels”,* and *“to preserve and maintain a thriving natural ecological balance and multiple-use relationship in that area*.” Title 43 CFR § 4700.0-6 (a) states “*Wild horses shall be managed as self- sustaining populations of healthy animals in balance with other uses and the productive capacity of their habitat*.” As the vegetative and water resources are over utilized and degraded to the point of no recovery as a result of wild horse overpopulation, wild horses would start showing signs of malnutrition and starvation. Habitat conditions would deteriorate as wild horse numbers above AML reduce herbaceous vegetative cover, damage springs, and increase erosion, and could result in irreversible damage to the rangelands. For these reasons, this alternative was eliminated from further consideration. This alternative would not meet the Purpose and Need for this analysis.

3.0 Affected Environment and Environmental Consequences

This section of the EA briefly discusses the relevant components of the human environment which may be affected by the action alternatives or No Action (Table 3-1).

3.1 General Description of the Affected Environment

The HMAs encompasses 196,181 acres in Lassen, Modoc, and Washoe counties in California and Nevada (Appendix A). Topography varies from gently rolling hills to deeply dissected canyons. Elevation varies from 4,800 feet to 8,200 feet. Annual precipitation averages 8 inches at lower elevations to 12 inches at the highest elevations. Temperatures also vary from -10 degrees Fahrenheit in the winter and 100 degrees Fahrenheit in the summer.

Domesticated horses were distributed widely across North America by the early 1700s, and the role of Native Americans in their spread has historically been underestimated (Taylor et al., 2023). The wild horses of northeastern CA and western NV are thought to be partially descendants of introduced Spanish horses, local ranch horses, and cavalry remounts (Amesbury, 1967), and other breeds of domestic horses that have been turned out to the public lands. It has been reported that in the 1860s two men brought 500 head of Spanish horses from San Diego, and drove some of them north to Buffalo Meadows, near Wild Horse Canyon. According to Amesbury, "…this was the start of the wild horse herds in this northern area," but it is very unlikely that the area lacked horses before that time.

More recently, horses were driven to Amedee (near Honey Lake), and shipped for use in the Boer War (1880), the Spanish-American War (1898), and World War I (1914) (Amesbury, 1967). During World War II, the Marr Ranch of the Madeline plains was involved in gathering wild horses from area now identified as Coppersmith, Buckhorn, and Twin Peaks HMAs for US Army remounts. During this time local residents attempted to improve the herd quality by culling horses with undesirable traits and introducing saddle horses with desirable traits into the herds. Genetic analyses indicate that wild horses in this area today have genetic influences that are predominantly from typical North American gaited breeds and light racing and riding breeds and can be interpreted as having some Spanish influence but with strong influence of cavalry remounts more recently (Appendix L). After World War II, and the decline in demand for remounts, some local wranglers captured the horses to be sold for horsemeat and pet food.

The first aerial inventories of the HMAs were undertaken by the BLM in 1973, 1974, and 1975, which noted 615 horses. Based on 2007 and 2011 capture data, horses in the HMAs predominantly exhibit bay, black, sorrel, and brown coat colors. However, many horses in these HMAs have varied colors, including palomino, gray, dun, grulla, buckskin, chestnut, pinto, and red roan. Horses within the HMAs are commonly 15 hands tall, of slight to moderate build, and average 800 to 1100 pounds in weight.

Vegetation is typical of sagebrush steppe with co-dominance of shrubs and native perennial grasses. Some wildfires have also occurred in the HMAs, resulting in conversions of sagebrush steppe to invasive, annual grass monocultures. Invasive grass monocultures are generally stable ecological states, in which recovery to native perennial grasses is not expected. In addition to a decline in biodiversity, wildfires have also exposed vulnerable soils to trampling resulting in increased wind and water erosion. Water is available through a variety of undeveloped streams, springs, and seeps, as well as developed water sources such as stock tanks, pits, troughs, wells, and reservoirs on public and private lands. These are scattered throughout the HMAs. Many of the undeveloped springs and seeps are ephemeral and produce water for only a few months in normal precipitation years. Many of them produce no water during below average precipitation years.

A more detailed description of the HMAs, history, and elements of the affected environment can be found in the 2009 Buckhorn, Coppersmith and Carter Reservoir Wild Horse Herd Management Area Capture and Remove Plan EA (DOI-BLM-CA-N070-2009-011-EA).

3.2 Description of Affected Resources and Environmental Consequences

Table 3-1 lists the elements of the human environment subject to requirements in statute, regulation, or executive order which were considered for detailed analysis. The BLM has discussed all the resources mentioned below and has either incorporated and analyzed them within this EA or provided an explanation of why they were not analyzed in detail. Resources that may be affected by the Proposed Action and alternatives were identified to be analyzed in detail. Resources that are not present or not affected by the Proposed Action and alternatives were considered but eliminated from detailed analysis.

Table 3-1. Supplemental authorities (i.e., critical elements of the human environment) for the Carter Reservoir, Buckhorn, and Coppersmith Herd Management Areas (HMAs).

Supplemental Authorities	Present	May Affect	Rationale
Area of Critical Environmental Concern (ACEC)	**NO**	**NO**	Not present.
Air Quality/Climate Change	**YES**	**NO**	Air quality in the planning area is generally good, with wildfire being the main source of impacts. BLM estimates the that Proposed Action would lead to 6.5 tons of PM_{10} emissions. Less than 1 ton of other criteria pollutants combines, and 90.5 tons CO_2e of greenhouse gas emissions. According to EPA, this is equivalent to the emissions from 22 cars operated for one year. This very small level of emissions is not expected to affect air quality or the current course of climate change in any discernable way.
Cultural Resources	**YES**	**YES**	To prevent any impacts to cultural resources, trap sites and temporary holding facilities would be located in previously surveyed areas. Cultural resource inventories and would be required prior to using trap sites or holding facilities outside existing areas of disturbance. Cultural resources would primarily be impacted under the No Action Alternative. This is further discussed in Sections 3.2.1, 4.2.1, and 4.3.1.
Environmental Justice	**NO**	**NO**	The Proposed Action would not have disproportionately high or adverse human health or environmental effects on minority or low-income populations due to no Environmental Justice in the project area.
Greater Sage-Grouse	**YES**	**YES**	This is further discussed in Sections 3.2.7, 4.2.7, and 4.3.7.
Farmlands, Prime or Unique	**NO**	**NO**	No Prime or Unique Farmlands (as defined by 7 CFR 657.5) are present in the HMAs.
Fish Habitat	**YES**	**NO**	Fish habitat would benefit from the removal of excess wild horses and burros by reducing year-round trampling and sediment loading.
Floodplains	**NO**	**NO**	Not present.
Forest/Woodlands	**YES**	**NO**	Juniper woodlands occurring in the HMAs would not be affected.
Fuels/Fire	**YES**	**YES**	This is further discussed in Sections 3.2.2, 4.2.2, and 4.3.2. However, fuel projects within the HMAs would not be affected.
Healthy and Safety	**YES**	**NO**	The health and safety of the public during gather operations would follow Observation Day Protocol and Ground Rules that have been used in recent gathers to ensure that the public remains at a safe distance and does not impede gather operations. Appropriate BLM staff would be present to ensure compliance with visitation protocols. These

			measures minimize the risks to the health and safety of the public, BLM staff and contractors, and to the wild horses and burros during the gather operations. The BLM also follows current policy and guidelines pertaining to Observation Days [BLM IM No. 2013-058].
Lands/Access	**NO**	**NO**	No new rights-of-ways or other land authorizations are required to implement the Proposed Action or alternatives.
Livestock Grazing	**YES**	**YES**	This is further discussed in Sections 3.2.3, 4.2.3, and 4.3.3.
Migratory Birds	**YES**	**YES**	This is further discussed in Sections 3.2.7, 4.2.7, and 4.3.7.
Native American Concerns	**YES**	**NO**	Native American consultation is ongoing, no concerns have been expressed to date.
Noxious Weeds	**YES**	**NO**	To prevent the risk for spread of noxious weeds, any noxious weeds or non-native invasive weeds would be avoided when establishing and accessing trap sites and holding facilities. Project Design Features (PDFs) and Standard Resource Protection Measures (SRPMs) to reduce the spread of noxious weeds by vehicles are discussed in the Programmatic Applegate Integrated Invasive Plant Management EA (DOI-BLM-CA-N020-2017-0017-EA). These PDFs and SRPMs would be followed under this EA. All trap sites, holding facilities, and camp sites would be surveyed prior to selection. A reduction of wild horse populations would reduce the occurrence of noxious weed sites across the landscape.
Recreation	**YES**	**NO**	Recreation infrastructure would not be impacted. Recreation use has occurred mainly in the form of wilderness recreation, hiking, camping, and hunting. Activities that have occurred with very low frequency are wildlife observation, nature study, and archaeological sightseeing.
Riparian Areas	**YES**	**YES**	This is further discussed in Sections 3.2.4, 4.2.4, and 4.3.4.
Socioeconomics	**YES**	**NO**	The Proposed Action or Alternatives would not affect the socioeconomic status of the counties or nearby towns.
Soil Resources	**YES**	**YES**	Impacts to soils would affect less than 1% of the HMAs and would be temporary under Alternatives 1, 2 and 3. Alternative 4 would have an impact to soils in areas where wild horses congregate, which would generally be around riparian areas. This is further discussed in Sections 3.2.5, 4.2.5, and 4.3.5.
Threatened and Endangered (T&E) Plant Species	**NO**	**NO**	There are no known populations of designated T&E plant species occurring within the Applegate Field Office Boundary.

T&E Wildlife Species	**NO**	**NO**	Not present.
Vegetation	**YES**	**YES**	This is further discussed in Sections 3.2.9, 4.2.9, and 4.3.9.
Visual Resources	**YES**	**NO**	Gather operations are temporary and would not impact visual resources within the HMAs.
Water Quality	**YES**	**NO**	Trap sites and temporary holding facilities would be located away from any water sources to avoid impacts to water quality. Any impacts to water sources used while horses are in route to trap sites would be temporary and would not significantly affect water quality.
Waste (Hazardous or Solid)	**NO**	**NO**	Not present.
Wild Horse and Burros	**YES**	**YES**	This is further discussed in Sections 3.2.6, 4.2.6, and 4.3.6.
Wild and Scenic Rivers	**NO**	**NO**	Not present.
Wilderness	**NO**	**NO**	Not present.
Wilderness Study Area	**YES**	**YES**	This is further discussed in Sections 3.2.7, 4.2.7, and 4.3.7.
Wildlife	**YES**	**YES**	This is further discussed in Sections 3.2.8, 4.2.8, and 4.3.8.

Critical elements of the human environment identified as present and potentially affected by the action alternatives (Alternatives 1, 2, and 3) and/or the No Action Alternative include: cultural resources, livestock grazing, upland vegetation, riparian and wetland resources, soil resources, wildlife (migratory birds, greater sage-grouse), and wild horses and burros. The affected environment relative to these resources is described below.

3.2.1 Cultural Resources

Affected Environment

Buckhorn, Carter Reservoir, and Coppersmith HMAs are all located within the ethnographic or traditional territory of the Northern Paiute; of the 22 bands that comprise the Northern Paiute, five are represented in the area encompassed by the HMAs. Carter Reservoir HMA falls within the area identified as being used by the *Agaipaninadokado* ("Fish Lake Eaters") and *Moadokado* ("Wild Onion Eaters") of Summit Lake, and the *Gidutidad* or *Kidütökadö* ("Groundhog Eaters") of Surprise Valley. Buckhorn and Coppersmith HMAs lie primarily within the area traditionally used by the *Kamodokado* ("Jack Rabbit Eaters") of Gerlach, Nevada and the *Sawadokado* ("Sagebrush Mountain Dwellers) of Winnemucca. Northern Paiute from other band areas likely passed through the project area as part of seasonal subsistence rounds as well. Many members of the *Kidütökadö* continue to reside at the Fort Bidwell Reservation and are represented as part of the Fort Bidwell Tribe today. Additional tribes with Northern Paiute membership and interest within the project area vicinity include Cedarville Rancheria, Reno-Sparks Indian Colony, Summit Lake Paiute Tribe, and Susanville Indian Rancheria. To date, consultation efforts with the aforementioned Tribes have yielded no additional concerns within the proposed project area, cultural resource specific (including sacred and/or religious sites, TCPs, traditional resource gathering areas) or otherwise, but these efforts would continue through the duration of the gather should questions, comments, or concerns arise. The Pit River Tribe have also expressed previous interest in wild horse and burro gathers field-office wide but have provided no comments or concerns to date for this gather. Further information on the Northern Paiute can be found in Fowler and Liljeblad (1986), Kelly (1932), King et al. (2004), and Stewart (1939); these references are incorporated here by reference.

Previous cultural resource inventories completed within Buckhorn, Carter Reservoir, and Coppersmith HMAs indicate that the area was used prehistorically for a wide array of resource procurement activities, and that both seasonal upland habitation and more permanent, year-round habitation on valley floors occurred throughout the region. In addition, seasonal, temporary campsites were established for purposes of resource procurement, including stone-tool materials, game, and plant resources. Other prehistoric resources common to the region include stacked rock features (cairns, placements, blinds, alignments) and rock art (petroglyph) sites. Initial prehistoric use of the area may have occurred as early as 12,000 years before present, with historic Euro-American settlement occurring during the mid-1800s. Historically, use of the project area and vicinity was predominately associated with sheep and cattle grazing, and historic resources identified in the area are related to early homesteading, ranching, emigrant and military trails, mining, and railroads.

The project area also includes portions of two Cultural Resource Management Areas (CRMA), Tuledad/Duck Flat and North Hays Range, which were designated because of high densities of significant cultural resource values. Buckhorn HMA contains 47,293 acres of the Tuledad/Duck Flat Cultural Resource Management Area (CRMA), Coppersmith HMA contains 13,130 acres of the Tuledad/Duck Flat CRMA, and within Carter Reservoir HMA there are 1,105 acres designated as part of the North Hays Range CRMA. The historic (1846) Applegate Emigrant Trail also passes through the southern extent of Carter Reservoir HMA. King et al. (2004) and the 2008 Surprise RMP contain further information on the archaeological resources present within the HMAs and surrounding vicinity.

Various Class II and III cultural resource inventories have been completed throughout the project area by BLM, academic, and cultural resource management (CRM) personnel since the early 1970s. This includes approximately 32,000 acres of survey and the identification of 661 sites within the HMAs, including 17,700 acres of survey and 436 sites in Buckhorn HMA, 3,750 acres of survey and 20 sites in Carter Reservoir HMA, and 10,550 acres of survey and 205 sites in Coppersmith HMA.

The most sensitive areas for cultural resources, both in terms of impacts and where those resource types are most prevalent, are those which have natural water sources such as springs and streams. Heavy historical livestock grazing (pre-1970s) prior to the implementation of current grazing standards severely impacted and damaged many cultural sites. Lithic scatters (reduction areas), habitation localities, and quarry sites are especially vulnerable because trampling and hoof action can displace, physically break, and/or otherwise alter and destroy artifacts and surface archaeological features. Sites damaged by livestock or wild horse grazing begin to erode as a result of soil displacement and compaction and vegetation loss as well, increasing loss of integrity over time until they are eventually completely destroyed. Grazing damage to cultural sites has historically been associated with cattle grazing, but since the implementation of changes in cattle grazing management practices in recent years, the observed damage has been caused by wild horse grazing.

Increasing populations of wild horses competing for limited access to water and food resources has resulted in significant impacts to cultural resources at riparian areas. In an effort to access water, horses have caused substantial ground disturbance from trampling and pawing the ground around spring sources and seeps. As a result, both prehistoric and historic artifacts and features at or nearby these water sources have been displaced and/or destroyed. In addition to the loss of some artifacts and features, these sites have suffered a loss of integrity and data potential that cannot be recovered.

Impacts Common to Action Alternatives (1, 2, and 3)

The gather and removal of excess wild horses is an action common to Alternatives 1, 2, and 3. Alternatives 1, 2, and 3 would result in minimal effects, including no direct impacts, to cultural resources within the proposed HMAs due to inventory and avoidance of proposed gather, trap, and holding sites, either during previous gathers or as needed for this proposed gather in advance of gather-related actions. Similarly, areas of tribal significance (sacred and/or religious sites, TCPs, traditional resource gathering areas) would be minimally affected, including no direct impacts, by Alternatives 1, 2, and 3 through tribal consultation efforts and mitigation through avoidance. To date, no areas of tribal significance have been identified by consulting Tribes. The gather and removal of excess wild horses would reduce future potential for soil compaction, artifact breakage, feature disturbance, and bare ground subject to erosion. Grazing by wild horses has likely affected a larger number of sites than is currently documented. By removing excess wild horses as described in Alternatives 1, 2, and 3, vegetation health and cover would improve, trampling, trailing, rolling, and wallowing by horses would be reduced, and disturbance potential to cultural resources would be improved (decreased).

Impacts of Alternative 4 (No Action)
The No Action Alternative (4) could be expected to result in continued or increased detrimental effects to cultural resources, particularly those around water sources where horses congregate. Increasing numbers of wild horses could intensify damage to archaeological sites, especially in areas adjacent to water or prone to erosion. This damage could be expected through loss of archaeological soil deposits near the surface, soil compaction, artifact breakage, feature damage, and increased bare ground exposing sites to looting and higher erosion potential. Wild horse overgrazing of upland areas where cultural resources are located could result in the substantial disturbance of sites as the vegetation cover is reduced and removed, leading to increased erosion and looting potential, and archaeological deposits are generally shallower with little vertical deposition in these areas suggesting surface disturbance at upland site types is magnified in that these types of sites generally only have surface manifestations.

3.2.2 Fuels/Fire
Affected Environment
Buckhorn, Carter Reservoir, and Coppersmith HMAs are all located in areas that are dominated by juniper (*Juniperus communis*), bitterbrush (*Purshia tridentata*), big sagebrush (*Artemisia tridentata*), low sagebrush (*Artemisia arbuscula*), squirreltail (*Elymus elymoides*), Idaho fescue (*Festuca idahoensis*), needlegrass (*Nassella viridula*) and cheat grass (Bromus tectorum). Maintaining a balance of grazing animals and controlling the timing and amount of forage that is consumed each year by wildlife, livestock, and wild horses is crucial to maintaining healthy upland plant communities within the HMAs. Appropriate grazing levels by large ungulates has been associated with the known benefits of reducing the cover, density, and volume of fuels, particularly fine fuels, on the landscape (Schmelzer et al., 2014). In turn, this reduces the probability and severity of catastrophic wildfires. Within the shrub and grasslands of the HMAs and surrounding areas, the fuel reducing benefits are known. Recent research has identified that grazing by many global herbivore species, including but not limited to horses, aids in the reduction of fuel loading and the impact of grazing by herbivores, including livestock, have long been recognized (Rouet-Leduc, 2021; Davies et al., 2010).

Year-round heavy grazing on upland vegetation from all ungulates reduces the overall amount of fuels available for wildfires but does not allow upland sites to recover from past disturbances and those areas are in danger of trending downward in ecological health and increasing in annual invasive grasses. Additionally, plant communities and sagebrush ecosystems that have been impacted in the past by wildfires and historic livestock grazing are vulnerable to losing more of their native perennial grass component when grazed at higher than moderate utilization levels (less than 60%) (USFS, 2017).

Impacts Common to Action Alternatives (1, 2, and 3)
The growing scientific literature has continued to affirm that even though grazing reduces fuel loading, proper grazing management is critical for the advancement of land health characteristics (Copeland et al., 2023). Soil health, hydrologic function, and biotic integrity are all impacted differently depending on the location, timing, duration, and intensity of grazing management (Hennig et al., 2021). Properly managed grazing is critical to achieve reductions in fuel loads while curbing the expansion of invasive annual grasses, promoting native perennial species, and protecting sensitive riparian habitats. Research continues to indicate

that a variable season of use contributes to site resiliency while repeated early-season, high intensity use, contributes to the degradation of rangelands and the expansion of annual grasses (Copeland et al., 2023; Davies et al., 2015; Davies et al., 2024). Moderate fall grazing of uplands has also been identified with the reduction of invasive annual grasses and the promotion of native perennial species (Copeland et al., 2023; Davies et al., 2010).

While the BLM is granted the duty of managing wild horses, the day-to-day movement of wild horses on the range is inherently unmanaged from a livestock management perspective (Davies & Boyd, 2019). With the exception of fencing, wild horses graze whatever location they want to, for whatever timing and duration they want to, and whatever intensity (amount) they want to. In more natural systems, predation may augment the location, timing, and duration. However, wild horses face very limited predation and subsequently impressive reproduction rates as a result (Garrott, 2018).

Under Alternatives 1, 2, and 3, the numbers of wild horses would be reduced, and maintained at AML, which would result in a short-term increase in the volume of fine fuels throughout the HMAs. This would be due to a reduction in total amount of forage consumed year-round by the wild horses on the HMAs and surrounding areas. The increase of fuels available, especially during the late summer months, could result in a theoretical increase in wildfires. Conversely, the removal of excess wild horses may reduce the long-term increase in areas dominated by annual invasive grasses (cheatgrass). Reducing the amount of future area potentially dominated by annual invasive grasses and would theoretically reduce the amount and frequency of future fires.

Impacts of Alternative 4 (No Action)
The No Action Alternative (4) could be expected to result in a continued decrease of the overall availability of fuels, particularly fine fuels, within the HMAs and surrounding areas. However, Alternative 4 would result in a continued increase in the number of wild horses above AML, which would have compounding impacts upon upland vegetation composition and the potential for future fires.

3.2.3 Livestock

Affected Environment
The affected environment for livestock grazing provides information on how ecosystems within the HMAs are being affected by multiple uses of the land, including livestock grazing permits. Adjustments to livestock grazing permits is outside of the scope of this assessment. Information about livestock grazing permits within the HMAs is provided below in Table 3-2.

All livestock permits within the HMAs have undergone multiple changes to permit terms and conditions over the past decades (see Appendix G). An Animal Unit Month (AUM) is the amount of forage needed to sustain one cow, five sheep, or five goats for a moth and the livestock active AUMs were reduced in both allotments when adjudication occurred in the 1960s. The decision to reduce the number of livestock grazing in the allotment was to promote healthy sustainable rangeland ecosystems. In recent years, the BLM has monitored livestock grazing utilization, conducted riparian functional assessments, and used other monitoring methods to determine if the active numbers are meeting allotment resource objectives. Active livestock use has been reduced as much as 45% within the last 10 years (see Appendix H). The BLM issues grazing permit renewals on a 10-year basis and makes adjustments as necessary to active numbers, AUMs, and season of use to meet land health standards.

The allotments within the HMA are mapped in Appendix F. There are a total of eighteen permits that authorize livestock grazing in these allotments annually. The cattle operators are authorized to use a total of 13,152 AUMs of forage each year. The allotments consist of various pastures grazed in a rest- and deferred-rotation.

Each allotment has specific terms and conditions defining turnout locations and seasons of use depending on the prior year's available water, climatic conditions, and actual use numbers. Annual meetings (Annual Operating Plans) are held prior to livestock turnout to plan deferment and livestock rotations. During drought years, livestock use may be limited or decreased due to lack of water availability. The BLM Rangeland Management Specialists work closely with operators on livestock distribution and movement during such years to limit excessive use on riparian areas. The season of use may vary by one to two weeks annually based upon forage availability, drought conditions, and other management criteria.

The BLM allocated forage for livestock use, and the management of cattle in the HMAs involves careful adherence to permit stipulations, particularly regarding livestock numbers and season-of-use restrictions. Decisions pertaining to the six grazing allotments are contained in the following documents:

1. BLM Environmental Assessment, DOI-BLM-CA-370-99-03-EA, *Tuledad Allotment Grazing Strategy and Related Projects* (1999)
2. BLM Environmental Assessment, DOI-BLM-CA-370-03-29-EA, *Sand Creek Allotment Livestock Grazing Authorization* (2004)
3. BLM Environmental Impact Statement, DOI-BLM-CA-N020-2008-0002-RMP-EIS, *Surprise Resource Management Plan and Record of Decision* (2008)
4. *Cowhead/Massacre Management Framework Plan*
5. *Tuledad/Home Camp Management Framework Plan*

Livestock grazing use is controlled by fencing, herding, and strategic placement of water and salt. Rest-rotation and/or deferred rotational grazing strategies are also employed. Under the rest rotation grazing strategy, a pasture is grazed for one season then rested for one or two growing seasons to allow sufficient recovery time for plant growth and vigor prior to being grazed again. Deferred grazing is the postponement of grazing on a pasture until a specified time. For example, when plants mature and seeds set, they are not as vulnerable to damage from grazing as they would be during spring growth, therefore grazing may be deferred until seed set. Other grazing strategies include early-on and early off grazing, turnout location rotation, delayed turnout, or a modified annual season-of-use. Annual adjustments to livestock grazing are made by the BLM according to forage availability and in response to below- or above-average precipitation.

Table 3-2 below includes the number of animals and AUMs that are permitted in each grazing allotment for cattle, the permitted season of use, and the type of grazing system used. See Appendix G for a more complete description of grazing management actions that are permitted on both grazing allotments within the HMAs. See Appendix H for summary of livestock actual use information for the allotments in the HMA since the 2009 gather in the HMAs.

Table 3-2. Cattle Grazing Summary in the HMAs

Livestock Grazing Allotment Name	No. of Grazing Permits	Kind of Livestock	No. of Livestock[1]	Active AUMs	Season of Use (Dates)	Associated HMA	Grazing System
Sand Creek	7	Cattle	107	158	4/1 - 5/15	Carter Reservoir HMA	5 pasture Rest Rotation with Deferred Use.
			35	194	4/15 – 9/30		
			81	447	4/16 – 9/30		
			104	574	4/16 – 9/30		

			150	755	5/1 – 9/30		
			113 180	961	4/16 – 4/30 5/1 – 9/30		
			101	558	4/16 – 9/30		
Sand Creek Total				**3,647**			
Tuledad	11	Cattle	102	563	4/16 – 9/30	Coppersmith HMA (North Pasture) Buckhorn HMA (South Pasture)	North and South Pastures divided into several use areas/fields. Cattle and sheep distributed within carrying capacity of each pasture, alternating turnout locations and designated hot season use areas.
		Sheep	1000	427	4/16 – 6/19		
		Cattle	415	2086	4/16 – 9/30		
		Cattle Cattle Sheep Sheep Sheep Sheep	184 379 3000 2000 2000 3000	4024	4/1 – 4/15 4/16 – 9/30 3/26 – 4/15 4/16 – 5/24 5/25 – 6/30 9/20 – 10/15		
		Cattle	44	133	4/15 – 7/15		
		Cattle	50 93	517	4/1 – 4/30 5/1 – 9/30		
		Cattle	7	21	4/15 – 7/15		
		Cattle	118	674	4/1 – 9/30		
		Cattle	40	241	4/1 – 9/30		
		Cattle	72	218	4/15 – 7/15		
		Cattle	62 135 65	601	4/1 – 4/15 4/16 – 7/16 7/17 – 9/30		
Tuledad Total				**9,505**			

[1]Livestock numbers are for the entire grazing allotment, and do not reflect the AUMs that would be allocated within each HMA, as only a portion of the grazing allotments fall within the HMAs.

Livestock use has varied since the 2009 wild horse gather. In 2020, the W-5 Cold Spring Fire burned over 143,430 acres of BLM and private lands within the HMAs. The fire altered entire plant communities within the burned area. Subsequent grazing management was altered as well. Appendix H shows the decreased livestock use in the two years following the fire. Livestock use fluctuated starting in 2021 as BLM worked with permittees to rest burned areas from livestock grazing. Additionally, many permittees do not use their full grazing preference most years because they are balancing their use with conditions on the ground (e.g., available water, pastures rested previous year, soil moisture conditions). Since 2009, permittees only use on average about 72% of full grazing preference (see Appendix H). This allows for rest from livestock grazing. However, wild horses and burros have free access to all areas year-round, thus livestock rest does not allow for complete rest for vegetative communities, especially in riparian areas which continue to be degraded by wild horses and burros.

Impacts Common to Action Alternatives (1, 2, and 3)
Wild horses directly compete with livestock for available forage and water. Alternatives 1, 2, and 3 would have less impact on social and economic values associated with livestock grazing operations than the No Action Alternative (4). Grazing systems for individual allotments are designed to function in a thriving natural ecological balance with wild horse populations within the established AML range. Within the established AML range, livestock operations and grazing systems would function properly, and forage plants would be less heavily utilized by excessive season-long wild horse grazing. Furthermore, livestock operators could improve pasture rotation by allowing for proper rest and defer spring rest in areas where year-round wild horse use has negatively impacted deep rooted perennial grasses and riparian areas.

Impacts of Alternative 1 and 2
With Alternatives 1 and 2, a thriving natural ecological balance would be achieved and maintained longer than with Alternative 3. A thriving natural ecological balance would not be achieved with Alternative 4. Alternatives 1 and 2 would allow for a longer recovery period for degraded range resources and less overall use of forage species and would result in healthier livestock and forage.

Impacts of Alternative 3
With Alternative 3, wild horse populations would exceed high AML again in four to five years after achieving low AML, and the benefits to livestock would be shorter-term than benefits resulting from Alternative 1 or Alternative 2. Additionally, livestock operators would be more likely to receive reductions in permits due to poor range condition from continual, yearlong grazing by wild horses under Alternative 3.

Impacts of Alternative 4 (No Action)
Utilization by authorized livestock has been directly impacted due to the overpopulation of wild horses, both within and outside the HMAs. Livestock operators have been asked by the BLM to voluntary reduce use in some areas due to the impacts of the wild horse population and drought conditions on range vegetation/forage conditions. Wild horses are currently using nearly three times more than their forage allocation resulting in heavy to severe utilization of vegetation. The indirect impacts of Alternative 4 include increased damage to the rangelands, continued competition between livestock, wild horses and wildlife for the available forage and water, reduced quantity and quality of forage and water, and undue hardship on the livestock operators who would continue to be unable to make use of the forage they are authorized to use. Additionally, further damage to range improvements such as water troughs and riparian protection fencing would also occur as a result of large numbers of horses concentrating in one location competing for water. This amount of use and destruction increases maintenance and labor costs to repair and inspect each development.

Allotment and pasture division fences become damaged by excess wild horses attempting to move out of areas where their numbers and resource competition has become so severe they have to move somewhere else to find food and/or water. When this occurs, livestock may be able to get through these areas of fence lines that were damaged by excess wild horses, therefore livestock may end up on an adjacent allotment in which they are not authorized to graze.

3.2.4 Riparian Areas

Affected Environment

Past uses include, but are not limited to, historical grazing by domestic livestock and wild horses, multiple large wildfires, numerous multi-year droughts that resulted in the loss of riparian vegetation and erosion of riparian soils. To mitigate effects to riparian areas, over the last 50 years, grazing management actions such as deferred rest rotation, riparian exclosures, and juniper reduction projects have been implemented.

Riparian and wetland sites within the HMAs are generally small (less than 1 acre) and are capable of providing water for a limited number of wildlife, livestock, and wild horses. A more complete description of riparian areas and wetland sites within the HMAs can be found in Appendix I, on pages 66-70, in the 2009 Buckhorn, Coppersmith, and Carter Reservoir Wild Horse Herd Management Areas Capture and Remove Plan. A few larger springs with associated wet meadows exist within the HMAs, and these sites are typically heavily used by livestock and wild horses. Green riparian vegetation available during the hot summer months is an attractant to grazing animals when adjacent upland vegetation becomes mature, dry, and loses nutritional value.

Figure 3-1. This wet meadow complex in the Coppersmith HMA shows heavy use and trailing as animals congregate in green, riparian areas during hot weather. This photo was taken in June when upland vegetation has become dry and mature. Large, connected bare ground patches are evident as is the drying of the lower meadow, which is a direct result of chronic, severe overuse. These springs were rated as Functional-At-Risk and Nonfunctional by an interdisciplinary team in 2018.

During drought years, and in seasons with less than average precipitation, many riparian areas are unable to store water past spring or early summer. Therefore, many riparian/wetland areas are not capable of providing water for any species during drought years. As a result of water sources drying up during a drought season, larger, perennial riparian systems receive a disproportionate amount of use, as shown in photos of Willow Lake Springs in the Buckhorn HMA (Figure 3-2) and Sand Creek in the Carter Reservoir HMA (Figure 3-3). This often leads to riparian systems becoming degraded from heavy use and soil loss occurs from a concentrated number of animals using limited perennial water sources.

Figure 3-2. Large, connected patches of bare ground are evident at Willow Lake Springs in the Buckhorn HMA, a severely degraded riparian system. Damage from wild horses and livestock has decimated the natural structure and capabilities of this system, intensifying soil loss, erosion, and loss of riparian vegetation.

Figure 3-3. Sand Creek, in the Carter Reservoir HMA, is suffering from soil erosion, compaction, bank shearing, and loss of vegetation due to severe, chronic overuse by livestock and wild horses. Many hydrologic functions have been lost within parts of the system.

Grazing by wildlife, livestock, and wild horses can impact riparian/wetland areas through trampling and/or grazing of riparian vegetation. When forage plants are overgrazed and trampled, desirable native species can be replaced by less desirable species that produce little or no forage value. Since wild horses graze year-round (unlike livestock where areas can be rested or deferred from grazing), wild horses can damage riparian areas and spring sites in late summer and fall when little green forage is available in the uplands. A decline in soil condition, plant cover, and plant species composition from trampling and overgrazing can result in bare soil and/or encourage the invasion and growth of noxious weeds or other invasive plants in riparian sites. Early spring grazing can also adversely affect vegetation resources as a result of trampling of wet soils, uprooting of seedlings, and damaging mature plants. These damaging effects are all occurring as a result of the overpopulation of wild horses in the HMAs.

Sensitive riparian and wetland areas are often the first to show impacts of degradation in arid environments such as the HMAs. Of the 34 individual riparian functional assessments conducted since the last gather in 2009, 53% (n = 18) rate as "Functional - At Risk. (FAR)." Of the 35% (n = 12) rated as "Proper Functioning Condition (PFC)" three are fenced to exclude wild horses and livestock. The remaining 12% (n = 4) were rated as "Nonfunctional (NF)" which means that biological, geomorphological, and hydrologic processes have been so severely disrupted that the spring is no longer providing ecosystem goods and services (Chambers et al., 2014; Figure 3-4). Locations of riparian functional assessments and more detailed report are located in a map in Appendix I.

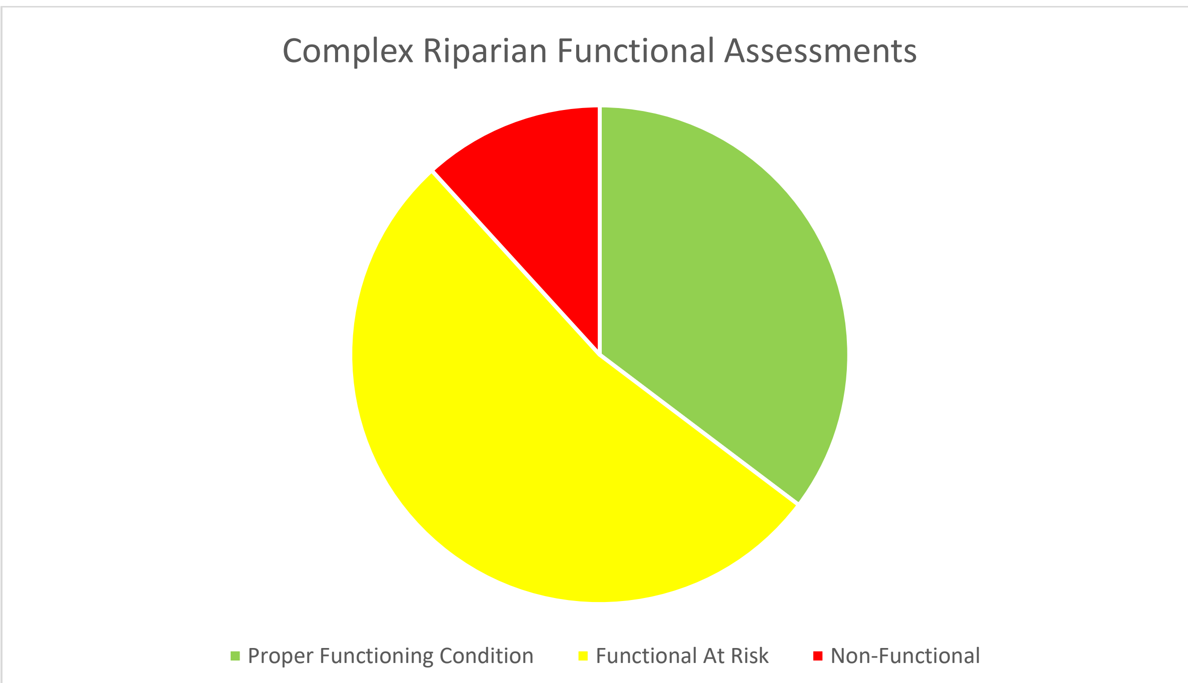

Figure 3-4. Riparian functional assessments were completed for 34 springs in the HMAs. Two thirds of the assessments were rated as either "Functional-At-Risk" or "Nonfunctional." The rest were rated as "Proper Functioning Condition."

Additionally, of the 11 springs that had repeated visits, two improved from a previous rating, four were static, meaning the rating had not changed, and five declined in rating due to continued overuse by wild horses.

Table 3-3. Repeat Assessment Ratings for HMAs Selected Springs.

HMA	Spring	Rating from 2009 EA	Rating from 2023 EA	Trend
Coppersmith	Ant Spring Exclosure	PFC	PFC	Static
	Sandstone Spring	FAR	FAR	Downward
	Little Tuledad Canyon Spring	FAR	PFC	Upward
	Juniper Seep	FAR	FAR	Upward
	Bare Creek	FAR	FAR	Downward
	Bird Bath Spring	PFC	PFC	Downward
	Little Hat Mtn #3	FAR	FAR	Static
Buckhorn	Rowland Spring Exclosure	FAR	PFC	Static
	Rowland Spring (Outside)	FAR	FAR	Static
	Burnt Lake Spring Area	FAR	NF	Downward
	Willow Lake Springs	FAR	NF	Downward

PFC = Proper Functioning Condition, FAR = Functional - At Risk, and NF= Nonfunctional

In general, springs are in fair to poor condition, with most at risk for losing further ecological structure and function. Loss of these springs would have dire consequences on the landscape, not only for wild horses, but also all livestock and wildlife species which depend on them for water and habitat.

Impacts of Alternatives 1, 2, and 3

Implementation of Alternatives 1, 2, and 3 would improve and protect springs, streams, and associated riparian and wetland communities by managing wild horses within established AML ranges. This would reduce direct impacts to many riparian and wetland sites from high use, continuous grazing, and ground disturbance from wild horses. Most of the riparian and wetland sites are currently rated as "Functioning-At-Risk" or "Nonfunctioning," mostly due to yearlong grazing pressure from excessive wild horses. Decreased grazing pressure from excessive wild horse use would allow these areas to recover and return to a healthier, better functioning condition.

Impacts of Alternative 1 & 2

Under Alternatives 1 & 2, recovery of riparian areas would likely be prolonged due to wild horse population management, as the population would be reduced to low AML and would be maintained within the AML range during the 10-year period. This would allow more opportunity for recovery of degraded riparian areas and for thriving natural ecological balance to be met and maintained.

Impacts of Alternative 3

Under Alternative 3, wild horse populations could grow to above upper AML within four years and riparian recovery would cease. Thriving natural ecological balance would fail to be met when wild horse populations rise above high AML.

Impacts of Alternative 4 (No Action)

Implementation of Alternative 4 would allow for increased numbers of wild horses above the established AML range to continue degrading riparian areas. Without a decrease in the wild horse populations, it is likely that the functional ratings of riparian areas would further decrease. It is estimated that with the projected increase in the wild horse population under this alternative over the next five years (based on the PopEquus population model), approximately 16 riparian/wetland sites within the HMAs could become severely degraded and/or dewatered transitioning from "Functional - At Risk" to "Nonfunctional."

3.2.5 Soil Resources

Affected Environment

Landforms that make up the HMAs vary from mountains to valley bottoms. Soil types within the HMAs are quite variable from loams to clays. The vertisol soils (montmorillonitic) in the HMAs are of particular concern, as they are easily destroyed if trampled when wet. Vertisols are clayey soils with very little organic matter and montmorillionitic soils are a subset of vertisols that have a unique physical and chemical structure that allows them to absorb more than twice their weight in water. When these soils are undisturbed, they are deep enough to support substantial plant production. When these soils are disturbed, the fragile clays become compacted and do not allow water to absorb into deeper horizons and reduce plant growth and survival. Seasonally controlled grazing can limit disturbance to these fragile soils when wet, but continuous, season-long grazing does not provide any protection against damage to soils. Once these soils are damaged, they can become unproductive and are vulnerable to invasion from annual grasses (e.g., medusahead). Loss of herbaceous cover and change in plant community composition negatively impacts soils. Soils within riparian areas and wetlands are extremely vulnerable to trampling by livestock and wild horses. A detailed description of the soils within the HMA can be found in the Soil Survey of Washoe County, Nevada, and California (NRCS, 2024a, 2024b, 2024c).

The soil surface community includes cyanobacteria, green algae, lichens, mosses, microfungi and other bacteria. Soils with these organisms are often referred to as cryptogamic soils and form biological crusts. The cyanobacteria and microfungal filaments aid in holding loose soil particles together, forming a biological crust (e.g., bryophytes) which stabilizes and protects soil surfaces (Belknap et al., 2001). Biological crusts benefit soils by increasing moisture retention, nitrogen fixation, and inhibiting annual plant growth. Most biological crust organisms grow during cool, moist conditions when soils are most vulnerable to trampling. Soils in the HMAs are at risk for degradation by trampling due to the overpopulation of wild horses.

Impacts of Alternatives 1, 2, and 3

Alternatives 1, 2, and 3 would result in the removal of excess horses to return the population to within AML. All three alternatives would result in short-term impacts to soils at gather site locations and temporary holding facilities. Some soils within these sites could become devoid of vegetation and be susceptible to soil erosion, however these areas are of limited size (typically less than 50 acres) and are expected to recover within a short period of time. The short-term effects to soils within these sites are outweighed by the long-term beneficial impacts to soil resources that would occur as a result of removing excess horses to within the established AML ranges.

Impacts of Alternative 4 (No Action)

Alternative 4 would result in the increase of wild horse numbers, which would increase the level of disturbance to vegetation and soils. Greater than 60% vegetation utilization levels as a result of livestock grazing or wild horse use in areas with sensitive soil types can degrade soils in both the short- and long-term through soil compaction, erosion, sedimentation, and degradation of stream channel conditions (George et al., 2011). Within the HMAs, soil compaction and erosion occur in areas where livestock, horses, concentrate (e.g., watering areas, salt locations, fence lines, and corrals) and vegetation has been reduced or removed. As wild horse populations continue to increase, the number of sites that would not meet the upland soils standard of the Standards for Rangeland Health would increase across the HMAs.

3.2.6 Wild Horses and Burros

Affected Environment

The Carter Reservoir HMA is a portion of the old New Years Lake HMA, which was established by the BLM Susanville District in 1973. Wild horses were removed from most of the New Years Lake HMA in 1980. The Carter Reservoir HMA is the only HMA remaining within the old New Years Lake HMA. The

remainder of what was formerly New Years Lake HMA was then renamed the New Years Lake Herd Area (HA) and is managed through BLM guidance and policy as an HA (BLM, 2010).
BLM designated the Buckhorn, Coppersmith HMAs in the Tuledad/Homecamp MFP/Record of Decision in 1979. The AML for the HMAs can be found in Table 1-4. AML was established for the HMAs in the 2008 Surprise Resource Management Plan (RMP), as amended. The last removal of excess wild horses from the HMAs was completed in 2009. At that time, 523 wild horses were gathered, of which 37 (12 studs and 25 mares) wild horses were released back to the range. All mares released were administered a fertility control vaccine (PZP, or Porcine Zona Pellucida, PZP-22) prior to their release. Appendix K provides details on number of animals removed by year.

Horses in the HMAs herds appear to be in overall good health with respect to body condition and genetic diversity. Few animals rate lower than a 3 Henneke body condition score. As the population increases, however, competition for resources, especially water in drought years, would likely lead to more animals in poorer body conditions. The most recent complete aerial survey of the HMAs were counted during an aerial population survey using the simultaneous double observer method in April and May 2022. Previous aerial surveys were completed from 2009 – 2023.

Because of history, context, and periodic introductions, wild horses that live in any of the HMAs in the HMAs are not a truly isolated population. The Carter Reservoir HMA is 10 miles from the nearest HMA boundary (Massacre Lakes HMA, administered by BLM Nevada), however with over 50% of the horses now residing outside the HMA boundaries, it is unclear how far some horses may have traveled mixing with other HMAs to the east and south. It is quite likely that, as horses disperse further from the Carter Reservoir HMA boundaries, they would encounter and interbreed with horses from other nearby HMAs with ever greater frequency. Some horses in the Carter Reservoir HMA have color markings that some members of the public associate with Spanish breed influence. The *dun* factor (noted as Dn+ in Sponenburg, 1996) is a single, dominant horse coat color allele at the TBX3 gene (Imsland et al., 2016) that interacts with other coat color genes to cause linebacked dun phenotype traits such as a dorsal stripe or withers stripe. The *dun* factor is present in some horses in the Carter Reservoir herd and many other BLM-managed wild horse herds across the west – including but not limited to Pryor Mountain HMA (Montana), Sulphur HMA (Utah), Kiger, Riddle, South Steens HMA. The presence of the *dun* factor alone does not indicate that an individual is highly related to Spanish horse breeds; many domestic horse breeds include lineback dun colored horses. The d-loop mitochondrial gene is one that can be used to assess maternal ancestry, in terms of a large number of mitochondrial haplotypes. External analysis of some horses from the Carter Reservoir HMA, contracted by a local interest group, has apparently documented the presence of the D type haplotype at this gene. Many domestic horse breeds have a variety of mitochondrial haplotypes. In some breeds, a particular haplotype is particularly common, but mitochondrial haplotype alone cannot generally be used to designate the ancestry or breed type of any given horse. For example, D haplotypes for the d-loop gene are present in some breeds of Iberian ancestry such as Lusitano and Garrano (Luis et al., 2006), but also a variety of other domestic breeds including Lipizzaner, Arabian, Shire, and Thoroughbred (Jansen et al., 2002).

The National Research Council (NRC) report to the BLM (2013) recommended that single HMAs or complexes should not be considered isolated genetic populations. Rather, managed herds of wild horses should be considered as components of interacting metapopulations, connected by interchange of individuals and genes due to both natural and human-facilitated movements. The animals in these three HMAs are part of part of a larger metapopulation (NRC, 2013) that has extensive demographic and genetic connections with other BLM-managed herds in California, Nevada, Oregon, and beyond. Origins of these three herds, documentation of past ecological conditions (up to 2010), and the history of AML and the HMA can be found in the 2009 Buckhorn, Coppersmith and Carter Reservoir Wild Horse Herd Management Areas Capture and Remove Plan EA (DOI-BLM-CA-N070-2009-011-EA). Horses from all three HMAs have a background of shared domestic breed heritage (Appendix L), and both natural movements and human-caused translocation of animals between herds. This background is very similar to that of many other wild

horse herds managed by the BLM. Genetic diversity data were collected at the last gather in 2011 and results are provided in Appendix L.
Based on samples analyzed in 2011, genetic diversity of the herds in all three HMAs (Appendix L) was generally above the targeted level for management, which is for observed heterozygosity to be within one standard deviation of the mean for feral herds (BLM, 2010). Genetic similarity measures among all three sampled HMAs suggested herds with mixed ancestry primarily of North American origin (Appendix L).

Although all three HMAs displayed an overall high-enough or above average diversity, Carter Reservoir results were slightly below the mean level of genetic diversity for feral herds (as measured by observed heterozygosity). However, although the observed heterozygosity value for Carter Reservoir samples was below the mean for feral herds, it was at a level that was within one standard deviation of that mean. Per the report, this low level was not low enough that it required immediate actions however monitoring and retesting was recommended, as recommended for all three herds.

During the initial gather, separate samples of hair follicles for genetic diversity analysis would be collected from each of the three herds to update the BLM's genetic diversity monitoring. There has been a long gap (14+ years) since hair follicle samples were analyzed, whereas a previous gap between genetic sampling from gathers was 7 years.

Under all action alternatives, wild horse introductions from other HMAs could be used if needed, to augment observed heterozygosity, which is a measure of genetic diversity, the result of which would be to reduce the risk of inbreeding-related health effects. Introducing a small number of fertile animals every generation (about every 8-10 years) is a standard management technique that can alleviate potential inbreeding concerns (BLM, 2010).

The 2013 National Research Council of the National Academies of Sciences report included other evidence that shows that any single HMA is particularly unusual genetically, with respect to other BLM-managed wild horse herds. One specific of this comes from Appendix F of the 2013 NRC report, which is a table showing the estimated 'fixation index' (Fst) values between 183 pairs of samples from wild horse herds. Fst is a measure of genetic differentiation, in this case as estimated by the pattern of microsatellite allelic diversity analyzed by Dr. Cothran's laboratory. Low values of Fst indicate that a given pair of sampled herds has a shared genetic background. The lower the Fst value, the more genetically similar are the two sampled herds. Values of Fst under approximately 0.05 indicate virtually no differentiation, values of 0.10 indicate very little differentiation, and only if values are above about 0.15 are any two sampled subpopulations considered to have evidence of elevated differentiation (Frankham et al., 2010). Fst values for HMAs had pairwise Fst values that were less than 0.05 with a large number of other sample sets – 132 for Buckhorn, 28 for Carter Reservoir, and 15 for Coppersmith. The number of other sample sets with pairwise Fst values under 0.075 (suggesting a level of differentiation somewhere between virtually none and very little) is even larger – with 171 such pairs for Buckhorn, 132 for Carter Reservoir, and 129 for Coppersmith.

More recently, Cothran et al. (2024) summarized genetic monitoring results from over 150 herds, and those results also indicate that each of these three HMAs are not genetically isolated or particularly unusual wild horse populations. In a Principle Components Analysis (PCA), the pattern of microsatellite allele frequencies placed these herds well within a cloud of similar such herds (Cothran et al., 2024). Also, based on allele frequencies and assignment tests, Cothran et al. (2024) inferred that there is recent genetic interchange between these HMAs and others such as Black Rock, Fox Hog, and Buffalo Hills, each of which also had stepping-stone type genetic interchange to a number of other HMAs. Along with the previously available Fst results (NRC, 2013) noted just above, all these results support the interpretation that wild horses in the three HMAs are part of a highly connected metapopulation that includes wild horse herds in many other HMAs.

Diet and Overlap
Numerous studies identify dietary overlap of preferred forage species and habitat preference between horses, cattle, and wildlife species in the Great Basin ecosystems for all seasons (Ganskopp, 1983; Ganskopp & Vavra, 1986, 1987; McInnis, 1984; McInnis & Vavra, 1987; Smith & Waggoner, 1982; Vavra & Sneva, 1978). A strong potential exists for exploitative competition between horses and cattle under conditions of limited forage (water and space) availability (McInnis & Vavra, 1987).

Although horses and cattle are often compared as grazers, horses can be more destructive to the range than cattle due to their differing digestive systems and grazing habits. The dietary overlap between wild horses and cattle is much higher than between wild horses and wildlife, and averages between 60 and 80% (Hubbard & Hansen, 1976; Hansen et al., 1977; Hanley, 1982; Krysl et al., 1984; McInnis & Vavra, 1987). Horses are cecal digesters while most other ungulates including cattle, pronghorn, and others are ruminants (Hanley & Hanley, 1982; Beever, 2003). Cecal digesters do not ruminate (i.e., have to regurgitate and repeat the cycle of chewing until edible particles of plant fiber are small enough for their digestive system). Ruminants, especially cattle, must graze selectively, searching out digestible tissue (Olsen & Hansen, 1977). Horses, however, are one of the least selective grazers in the West because they can consume high fiber foods and digest larger food fragments (Hanley & Hanley, 1982; Beever, 2003; Bauer et al., 2017). To do so, though, horses must consume a lot of water so free-ranging horses have a high affinity for habitats that are close to water, which appears to be stronger than for like-sized ruminants (Esmaeili et al., 2021).

Wild horses can exploit the high cellulose of graminoids, or grasses, which have been observed to make up over 88% of their diet (McInnis & Vavra, 1987; Hanley, 1982). However, this lower quality diet requires that horses consume 20-65% more forage than a cow of equal body mass (Hanley, 1982; Menard et al., 2002). With more flexible lips and upper front incisors, both features that cattle do not have, wild horses trim vegetation more closely to the ground (Symanski, 1994; Menard et al., 2002; Beever, 2003). As a result, areas grazed by horses may retain fewer plant species and may be subject to higher utilization levels than areas grazed by cattle or other ungulates. A potential benefit of a horse's digestive system may come from seeds passing through system without being digested but the benefit is likely minimal when compared to the overall impact wild horse grazing has on vegetation in general. Wild horses can spread nonnative plant species, including cheatgrass, and may limit the effectiveness of habitat restoration projects (Beever et al., 2003; Couvreur et al., 2004; Jessop & Anderson, 2007; Loydi & Zalba, 2009; King et al., 2019).

Effects of Wild Horses and Burros on Rangeland Ecosystems
The presence of wild horses and wild burros can have substantial effects on rangeland ecosystems, and on the capacity for habitat restoration efforts to achieve landscape conservation and restoration goals. While wild horses and burros may have some beneficial ecological effects, such benefits are outweighed by ecological dam age they cause when herds are at levels greater than supportable by allocated, available natural resources (i.e., when herds are greater than AML).

In the biological sense, all free-roaming horses and burros in North America are feral, meaning that they are descendants of domesticated animals brought to the Americas by European colonists. Horses went extinct in the Americas by the end of the Pleistocene, about 10,000 years ago (Webb, 1984; MacFadden, 2005). Burros evolved in Eurasia (Geigl et al., 2016). The published literature refers to free-roaming horses and burros as either feral or wild. In the ecological context the terms are interchangeable, but the terms 'wild horse' and 'wild burro' are associated with a specific legal status. Whether or not those animals were continuously present throughout the Holocene period in the 10 states where they are currently managed does not appear to influence the magnitude or direction of their ecological effects (Lundgren et al., 2024), but those effects are by no measure benign with respect to less well-known plant and animal species, many of which have far more limited geographic distributions. The following literature review on the effects of wild horses and burros on rangeland ecosystems draws on scientific studies of feral horses and burros, some of which also have wild horse or wild burro legal status. The following literature review draws on Parts 1 and 2 of the

'Science framework for conservation and restoration of the sagebrush biome' interagency report (Chambers et al., 2017; Crist et al., 2019).

Because of the known damage that overpopulated wild horse and burro herds can cause in rangeland ecosystems, the presence of wild horses and burros is considered a threat to Greater sage-grouse habitat quality, particularly in the bird species' western range (Beever & Aldridge, 2011; USFWS, 2013). Wild horse population sizes on federal lands have more than doubled in the five years since the USFWS report (2013) was published (BLM, 2018). On lands administered by the BLM, there were over 95,000 BLM-administered wild horses and burros as of March 1, 2020, which does not include foals born in 2020. Lands with wild horses and burros are managed for multiple uses, so it can be difficult to parse out their ecological effects. Despite this, scientific studies designed to separate out those effects, which are summarized below, point to conclusions that landscapes with greater wild horse and burro abundance would tend to have lower resilience to disturbance and lower resistance to invasive plants than similar landscapes with herds at or below target AML levels.

In contrast to managed livestock grazing, neither the seasonal timing nor the intensity of wild horse and burro grazing can be managed, except through efforts to manage their numbers and distribution. Wild horses live on the range year-round, they roam freely, and wild horse populations have the potential to grow 15-20% per year (Wolfe, 1980; Eberhardt et al., 1982; Garrott et al., 1991; Dawson, 2005; Roelle et al., 2010; Scorolli et al., 2010). Although this annual growth rate may be lower in some areas where mountain lions can take foals (Turner & Morrison, 2001; Turner, 2015), horses tend to favor use of more open habitats (Schoenecker, 2016) that are dominated by grasses and shrubs and where ambush is less likely. Horses can compete with managed livestock in forage selected (Scasta et al., 2016). For the majority of wild horse herds, there is little overall evidence that population growth is significantly affected by predation. As a result of the potential for wild horse populations to grow rapidly, impacts from wild horses on water, soil, vegetation, and native wildlife resources (Davies & Boyd, 2019) can increase exponentially unless there is active management to limit their population sizes.

The USFWS (2008), Beever and Aldridge (2011), and Chambers et al., (2017) summarize much of the literature that quantifies direct ecosystem effects of wild horse presence. Beever and Aldridge (2011) present a conceptual model that illustrates the effects of wild horses on sagebrush ecosystems. In the Great Basin, areas without wild horses had greater shrub cover, plant cover, species richness, native plant cover, and overall plant biomass, and less cover percentage of grazing-tolerant, unpalatable, and invasive plant species, including cheatgrass, compared to areas with horses (Smith, 1986a; Beever et al., 2008; Davies et al., 2014; Zeigenfuss et al., 2014; Boyd et al., 2017). There were also measurable increases in soil penetration resistance and erosion, decreases in ant mound and granivorous small mammal densities, and changes in reptile communities (Beever et al., 2003; Beever & Brussard, 2004; Beever & Herrick, 2006; Ostermann-Kelm et al., 2009). Intensive grazing by horses and other ungulates can damage biological crusts (Belnap et al., 2001). In contrast to domestic livestock grazing, where post-fire grazing rest and deferment can foster recovery, wild horse grazing occurs year-round. These effects imply that horse presence can have broad effects on ecosystem function that could influence conservation and restoration actions.

Many studies corroborate the general conclusion that wild horses can lead to biologically significant changes in rangeland ecosystems, particularly when their populations are overabundant relative to water and forage resources, and other wildlife living on the landscape (Eldridge et al., 2020). The presence of wild horses is associated with a reduced degree of greater sage-grouse lekking behavior (Muñoz et al., 2020). Moreover, increasing densities of wild horses, measured as a percentage above AML, are associated with decreasing greater sage-grouse population sizes, measured by lek counts (Coates et al., 2021). Horses are primarily grazers (Hanley & Hanley, 1982), but shrubs – including sagebrush – can represent a large part of a horse's diet, at least in summer in the Great Basin (Nordquist, 2011). Grazing by wild horses can have severe impacts on water source quality, aquatic ecosystems, and riparian communities as well (Beever & Brussard, 2000; Barnett, 2002; Nordquist, 2011; USFWS, 2008; Earnst et al., 2012; USFWS, 2012, Kaweck et al., 2018), sometimes excluding native ungulates from water sources (Ostermann-Kelm et al., 2008; USFWS, 2008; Perry et al., 2015; Hall et al., 2016; Gooch et al., 2017; Hall et al., 2018). Impacts to riparian vegetation per individual wild horse can exceed impacts per individual domestic cow (Kaweck et al., 2018). Bird nest survival may be lower in areas with wild horses (Zalba & Cozzani, 2004), and bird populations have recovered substantially after livestock and/or wild horses have been removed (Earnst et al., 2005; Earnst et al., 2012; Batchelor et al., 2015). Wild horses can spread nonnative plant species, including cheatgrass, and may limit the effectiveness of habitat restoration projects (Beever et al., 2003; Couvreur et al., 2004; Jessop & Anderson, 2007; Loydi & Zalba, 2009). Riparian and wildlife habitat improvement projects intended to increase the availability of grasses, forbs, riparian habitats, and water would likely attract and be subject to heavy grazing and trampling by wild horses that live in the vicinity of the project. Even after domestic livestock are removed, continued wild horse grazing can cause ongoing detrimental ecosystem effects (USFWS, 2008; Davies et al., 2014) which may require several decades for recovery (Anderson & Inouye, 2001).

Wild horses and burros may have beneficial effects, but those benefits do not typically outweigh damage caused when herd sizes are high, relative to available natural resources. Under some conditions, there may not be observable competition with other ungulate species for water (Meeker, 1979), but recent studies that used remote cameras have found wild horses excluding native wildlife from water sources under conditions of relative water scarcity (Perry et al., 2015; Hall et al., 2016; Hall et al., 2018). Compared to landscapes where large herbivores such as horses and burros are completely absent, the presence of some large herbivores can cause local-scale ecological disturbances that may increase local species diversity (Trepel et al., 2024); this is consistent with the intermediate disturbance hypothesis (Wilkinson, 1999), which also predicts that excessive disturbance, such as may be associated with wild horse herds far above AML, leads to reduced species diversity. Wild burros (and, less frequently, wild horses) have been observed digging ‘wells;’ such digging may improve habitat conditions for some vertebrate species and, in one site, may improve tree seedling survival (Lundgren et al., 2021). This behavior has been observed in intermittent stream beds where subsurface water is within 2 meters of the surface (Lundgren et al., 2021). The BLM is not aware of published studies that document wild horses or burros in the western United States causing similar or widespread habitat amelioration on drier upland habitats such as sagebrush, grasslands, or pinyon-juniper woodlands. Lundgren et al. (2021) suggested that, due to well-digging in ephemeral streambeds, wild burros (and horses) could be considered ‘ecosystem engineers;’ a term for species that modify resource availability for other species (Jones et al., 1994). In HMAs where wild horse and burro biomass is very large relative to the biomass of native ungulates (Boyce & McLoughlin, 2021), they should probably also be considered ‘dominant species’ (Power & Mills, 1995) whose ecological influences result from their prevalence on the landscape. Wild horse densities could be maintained at high levels in part because artificial selection for early or extended reproduction may mean that wild horse population dynamics are not constrained in the same way as large herbivores that were never domesticated (Boyce & McLoughlin, 2021). Equids redistribute organic matter and nutrients in dung piles (King & Gurnell, 2006), which could disperse and improve germination of undigested seeds. This could be beneficial if the animals spread viable native plant seeds but could have negative consequences if the animals spread viable seeds of invasive plants such as cheatgrass (Loydi & Zalba, 2009; King et al., 2019). Increased wild horse and burro density would be expected to increase the spatial extent and frequency of seed dispersal, whether the seeds distributed are desirable or undesirable. As is true of herbivory by any grazing animals, light grazing can increase rates of nutrient cycling (Manley et al., 1995) and foster compensatory growth in grazed plants which may stimulate root growth (Osterheld & McNaughton, 1991; Schuman et al., 1999) and, potentially, an increase in carbon sequestration in the soil (Derner & Schuman, 2007; He et al., 2011). However, when grazer density is high relative to available forage resources, overgrazing by any species can lead to long-term reductions in plant productivity, including decreased root biomass (Herbel, 1982; Williams et al., 1968) and potential reduction of stored carbon in soil horizons. Recognizing the potential beneficial effects of low-density wild horse and burro herds, but also recognizing the totality of available published studies documented ecological effects of wild horse and burro herds, especially when above AML (see preceding paragraphs), it is prudent to conclude that horse and burro herd sizes above AML may cause levels of disturbance that reduce landscapes' capacity for resilience in the face of further disturbance, such as is posed by extreme weather events and other consequences of climate change.

Most analyses of wild horse effects have contrasted areas with wild horses to areas without, which is a study design that should control for effects of other grazers, but historical or ongoing effects of livestock grazing may be difficult to separate from horse effects in some cases (Davies et al., 2014). Analyses have generally not included horse density as a continuous covariate; therefore, ecosystem effects have not been quantified as a linear function of increasing wild horse density. One exception is an analysis of satellite imagery confirming that varied levels of feral horse biomass were negatively correlated with average plant biomass growth (Ziegenfuss et al., 2014).

Horses require access to large amounts of water; an individual can drink an average of 7.4 gallons of water per day (Groenendyk et al., 1988). Despite a general preference for habitats near water (Crane et al., 1997), wild horses have been found to routinely commute long distances (e.g., 10+ miles per day) between water sources and palatable vegetation (Hampson et al., 2010).
Wild burros can also substantially affect riparian habitats (Tiller, 1997), native wildlife (Seegmiller & Ohmart, 1981), and have grazing and trampling impacts that are similar to wild horses (Carothers et al., 1976; Hanley & Brady, 1977; Douglas & Hurst, 1993). Where wild burros and Greater sage-grouse co-occur, burros' year-round use of low-elevation habitats may lead to a high degree of overlap between burros and Greater sage-grouse (Beever & Aldridge, 2011).

Intraspecific Competition
Wild horses also compete with wildlife species for various habitat components, especially when populations exceed AML and/or habitat resources become limited (i.e., reduced water flows, low forage production, dry conditions, etc.). Smith (1986a, b) determined that elk and bighorn sheep were the most likely to negatively interact with wild horses. Hanley and Hanley (1982) compared the diets of wild horses, domestic cattle and sheep, pronghorn antelope, and mule deer and found that horse and cattle diets consisted mostly of grasses, pronghorn and mule deer diets consisted mostly of shrubs (>90%) and sheep diets were intermediate. Due to different food preferences, diet overlap between wild horses, deer, and pronghorn rarely exceeds 20% (Hubbard & Hansen, 1976; Hansen et al., 1977; Meeker, 1979; Hanley & Hanley, 1982). Impacts to riparian vegetation per individual wild horse can exceed impacts per individual domestic cow (Kaweck et al., 2018).

There is growing concern about limited water and forage available to wild horses, livestock, and wildlife in the desert climate of the Great Basin (Gooch et al., 2017; Hall et al., 2016). Heavy use of forage near available water and competition between wild horses, livestock, and wildlife for limited forage and water has increased (Ostermann-Kelm et al., 2008; USFWS, 2008; Perry et al., 2015; Hall et al., 2016; Gooch et al., 2017; Hall et al., 2018). The effects of climate change may include prolonged and more frequent drought conditions, and maintaining wild horse herds at levels within AML should help BLM managers to ensure that adequate water and forage resources are available for the wild horses and wildlife living in these HMAs, into the future, as well as providing for multiple uses as required by FLPMA.

Livestock permittees often haul water, transport water in water pipelines, or pump wells to provide water for their livestock. Because there are limited sources of water in the HMA, the wild horses and burros tend to stay closer to, and concentrate around, those sources of water. Forage around the water sources is heavily impacted because of the high concentration of wild horses in that area. Wild horses and burros have to travel greater distances to meet both their forage and water needs. Increasing competition at the water source, can cause increased stress to the animals and can lead to emergency conditions where a failure to take action may result in the suffering or death of individual wild horses.

Given the dry conditions that occur annually in the summertime, and the expanding wild horse numbers along with the limited perennial water sources in the HMAs, there is a real concern that wild horses and burros could suffer from dehydration and possible death. If their known or common (habitual) water sources become dry or unavailable wild horses have been found to linger sometimes until death, instead of searching out new or unknown water sources. Horse herd sizes over AML can also be considered in light of expected effects of climate change. Severe drought conditions may worsen and become more frequent. High herd densities using limited water supplies could reasonably be expected to exacerbate behavioral conflict at water sources, and to cause even greater levels of habitat degradation because of excessive habitat use near those water sources.

Results of PopEquus Population Modeling
The Alternatives (1, 2, 3, and 4) were modeled using *PopEquus* population model designed by USGS (USGS, 2023). Alternatives 2,3, and 4 were modeled together as PopEquus allows for multiple alternatives to be calculated. The purpose of the modeling was to analyze and compare the effects of the action alternatives on population size, average population growth rate, and average removal number. Alternatives 1, 2 and 3 all reduce the population. Alternative 4 results in a large population increase that could result in over 3,000 horses within 10 years (average numbers from *PopEquus* modeling; Appendix M).

Impacts of Alternative 1 (Proposed Action)
This alternative would adjust the sex ratio of the herd that is returned to the range which would affect population dynamics and herd structure. Under Alternative 1, due to effects of sex ratio manipulation (Appendix N) band size would be expected to decrease, competition for mares would be expected to increase, recruitment age for reproduction among mares would be expected to decline, and size and number of bachelor bands would be expected to increase. These effects would be slight, as the proposed sex ratio (60% male) is not an extreme departure from normal sex ratio ranges. Modification of sex ratios for a post-gather population with more stallions than mares would further reduce growth rates in combination with fertility control. Sex ratio adjustment would also decrease the number of mares which would need to be handled for fertility control, thus reducing stress to individual animals.

Impacts Common to Alternatives (1 and 2)
Contraception
All fertility control methods in wild animals are associated with potential risks and benefits, including effects of handling, frequency of handling, physiological effects, behavioral effects, and reduced population growth rates (Hampton et al., 2015). Contraception by itself does not remove excess horses from an HMA's population. If a wild horse population is in excess of AML, then contraception alone would result in some continuing environmental effects of overpopulation. Successful contraception reduces future reproduction.

Successful contraception would be expected to reduce the frequency of gather activities, as well as wild horse management costs to taxpayers. Bartholow (2007) concluded that the application of 2 or 3-year contraceptives to wild mares could reduce operational costs in a project area by 12 to 20%, or up to 30% in carefully planned population management programs. He also concluded that contraceptive treatment would likely reduce the number of horses that must be removed in total, with associated cost reductions in the number of private placements and total holding costs. Population suppression becomes less expensive if fertility control is long-lasting (Hobbs et al., 2000). BLM acknowledges that mares treated repeatedly with fertility control vaccines may become infertile for the rest of their life, which could also be termed sterile (Nuñez, 2018), even though the mechanism of activity for immunocontraceptive vaccines is different than for a physical sterilization procedure. Although contraceptive vaccines and IUDs may be associated with a number of potential physiological, behavioral, demographic, and genetic effects, detailed in Appendix N, those concerns do not generally outweigh the potential benefits of using contraceptive treatments in situations where it is a management goal to reduce population growth rates (Garrott & Oli, 2013).

Fertility Control Vaccines

Fertility control vaccines (also known as immunocontraceptives) meet the BLM requirements for safety to mares and the environment (EPA, 2009, 2012). Because they work by causing an immune response in treated animals, there is no risk of hormones or toxins being taken into the food chain when a treated mare dies. The BLM and other land managers have mainly used three fertility control vaccine formulations for fertility control of wild horses and burros on the range: ZonaStat-H, PZP-22, and GonaCon-Equine. As other formulations become available, they may be applied in the future.

In any vaccine, the antigen is the stimulant to which the body responds by making antigen-specific antibodies. Those antibodies then signal to the body that a foreign molecule is present, initiating an immune response that removes the molecule or cell. Adjuvants are additional substances that are included in vaccines to elevate the level of immune response. Adjuvants help to incite recruitment of lymphocytes and other immune cells which foster a long-lasting immune response that is specific to the antigen.

Booster doses can be safely administered by hand or by dart. Even with repeated booster treatments of the vaccines, it is expected that most mares would eventually return to fertility, though some individual mares treated repeatedly may remain infertile. Once the herd size in a project area is at AML and population growth seems to be stabilized, the BLM can make adaptive determinations as to the required frequency of new and booster treatments.

The BLM would follow standard operating and post-treatment monitoring procedures for fertility control vaccine application (BLM Instruction Memorandum 2009-090: https://www.blm.gov/policy/im-2009-090). Herds selected for fertility control vaccine use should have annual growth rates over 5% and a herd size over 50 animals. The procedure requires that treated mares be identifiable via a visible freeze marked or individual color markings, so that their vaccination history can be known. The procedure calls for follow-up population surveys to determine the realized annual growth rate in herds treated with fertility control vaccines.

Porcine Zona Pellucida (PZP) Vaccine

A formulation of PZP vaccine may be applied to mares prior to their release back into the HMAs during gather actions. The PZP vaccines ZonaStat-H and PZP-22 meet most of the criteria that the National Research Council (2013) used to identify promising fertility control methods, in terms of delivery method, availability, efficacy, and side effects (see Appendix N). ZonaStat-H is relatively inexpensive, meets BLM requirements for safety to mares and the environment, and is an EPA-registered commercial product (EPA, 2012; SCC, 2015). PZP-22 is a formulation of PZP vaccine which includes polymer pellets that may lead to a longer immune response (Turner et al., 2002; Rutberg et al., 2017; Carey et al., 2019).

For the PZP-22 vaccine pellet formulation administered during gathers, each released female would receive a single dose of the PZP contraceptive vaccine pellets at the same time as a dose of the liquid PZP vaccine with modified Freund's Complete adjuvant. Most females recover from the stress of capture and handling quickly once released back into the HMA and none are expected to suffer serious long-term effects from the injections, other than the direct consequence of becoming temporarily infertile. Injection site reactions associated with fertility control treatments are possible in treated animals (Roelle & Ransom, 2009; Bechert et al., 2013; French et al., 2017), but swelling or local reactions at the injection site are expected to be minor in nature. In subsequent years, Native PZP (or currently most effective formulation) could be administered as a booster dose using the one-year liquid PZP vaccine by field or remote darting. The dart-delivered formulation produced injection-site reactions of varying intensity, though none of the observed reactions appeared debilitating to the animals (Roelle & Ransom, 2009). Joonè et al. (2017a) found that injection site reactions had healed in most mares within 3 months after the booster dose, and that they did not affect movement or cause fever. Application of fertility control treatment would be conducted in accordance with the approved standard operating and post-treatment monitoring procedures (SOPs, Appendix E).

The historically accepted hypothesis explaining PZP vaccine effectiveness posits that when injected as an antigen in vaccines, PZP causes the mare's immune system to produce antibodies that are specific to zona pellucida proteins on the surface of that mare's eggs. The antibodies bind to the mare's eggs surface proteins (Liu et al., 1989), and effectively block sperm binding and fertilization (Zoo Montana, 2000). Because treated mares do not become pregnant but other ovarian functions remain generally unchanged, PZP can cause a mare to continue having regular estrus cycles throughout the breeding season. Other research has shown, though, that there may be changes in ovarian structure and function due to PZP vaccine treatments (Joonè et al., 2017b; 2018). Research has demonstrated that contraceptive efficacy of an injected liquid PZP vaccine, such as ZonaStat-H, is approximately 90% or more for mares treated twice in one year (Turner & Kirkpatrick, 2002; Turner et al., 2008). The highest success for fertility control has been reported when the vaccine has been applied November through February. High contraceptive rates of 90% or more can be maintained in horses that have a booster annually with liquid PZP (Kirkpatrick et al., 1992). The rate of long-term or permanent sterility following vaccinations with PZP is hard to predict for individual horses, but that outcome appears to increase in likelihood as the number of doses increases (Kirkpatrick & Turner, 2002). This form of vaccine-induced long-term infertility or sterility for mares treated consecutively in each of 5-7 years was observed by Nuñez et al. (2010, 2017). Approximately 60% to 85% of mares are successfully contracepted for one year when treated simultaneously with a liquid primer and PZP-22 pellets (Rutberg et al., 2017). The application of PZP for fertility control would reduce fertility in a large percentage of mares for at least one year (Ransom et al., 2011). Detailed effects of PZP vaccines are located in Appendix N.

Gonadotropin Releasing Hormone (GnRH) Vaccine (GonaCon)
GonaCon-Equine vaccine may be applied to animals prior to their release back into the HMAs. Taking into consideration available literature on the subject, the National Research Council concluded in their 2013 report that GonaCon-B (which is produced under the trade name GonaCon-Equine for use in feral horses) was one of the most preferable available methods for contraception in wild horses (NRC, 2013), in terms of delivery method, availability, efficacy, and side effects (see Appendix N). The BLM may apply GonaCon-Equine to captured mares and would return to the HMAs as needed to re-apply GonaCon-Equine, including by recapture and/or remote darting. GonaCon-Equine can safely be reapplied (Baker et al., 2018, 2023) as necessary to control the population growth rate. GonaCon-Equine is approved for use by authorized federal, state, tribal, public, and private personnel, for application to wild and feral equids in the United States (EPA, 2013; 2015). GonaCon is approved for use in California and Nevada.

GonaCon is an immunocontraceptive vaccine which has been shown to provide multiple years of infertility in several wild ungulate species, including horses (Killian et al., 2008; Gray et al., 2010). GonaCon uses the gonadotropin-releasing hormone (GnRH), a small neuropeptide that performs an obligatory role in mammalian reproduction, as the vaccine antigen. When combined with an adjuvant, the GnRH vaccine stimulates a persistent immune response resulting in prolonged antibody production against GnRH, the carrier protein, and the adjuvant (Miller et al., 2008). The most direct result of successful GnRH vaccination is that it has the effect of decreasing the level of GnRH signaling in the body, as evidenced by a drop in luteinizing hormone levels, and a cessation of ovulation. The lack of estrus cycling that results from successful GonaCon vaccination has been compared to typical winter period of anoestrus in open mares. As anti-GnRH antibodies decline over time, concentrations of available endogenous GnRH increase and treated animals usually regain fertility (Power et al., 2011).

Changes in hormones associated with anti-GnRH vaccination led to measurable changes in ovarian structure and function. The volume of ovaries reduced in response to treatment (Garza et al., 1986; Dalin et al., 2002; Imboden et al., 2006; Elhay et al., 2007; Botha et al., 2008; Gionfriddo et al., 2011; Dalmau et al., 2015). Treatment with an anti-GnRH vaccine changes follicle development (Garza et al., 1986; Stout et al., 2003; Imboden et al., 2006; Elhay et al., 2007; Donovan et al., 2013; Powers et al., 2011; Balet et al., 2014), with the result that ovulation does not occur.

As with PZP vaccines, mares that are treated with GonaCon-equine vaccine can be expected to return to fertility when the immune response to the antigen declines; in the colloquial usage of the term, this also makes GonaCon-equine a 'reversible' treatment, even though the return to fertility is not under direct human control in the same sense that a narcotic drug can be 'reversed' by application of naloxone, for example. GonaCon-Equine can safely be reapplied as necessary to control the population growth rate; booster dose effects may lead to increased effectiveness of contraception, which is generally the intent. The longer the time between primer and booster, generally the longer-lasting was the contraceptive effect. Even with one booster treatment of GonaCon-Equine, it is expected that most, if not all, mares would return to fertility at some point. Baker et al. (2023) noted the possibility that some mares treated twice with GonaCon-Equine vaccine could remain contracepted for over 6 years, or even until they die; the latter outcome would presumably depend on the animal's age when treated, with older animals more likely to die before regaining fertility simply because their lifespan may not be long enough for the immune reaction to wane and cause a resumption of fertility. If long-term treatment resulted in such a long duration of immune response that a mare remains infertile until death, that type of permanent infertility would be consistent with the desired effect of using GonaCon (e.g., effective contraception), and with section 1333(b) of the WFRHBA.

As is true for PZP vaccines, injection site reactions associated with immunocontraceptive treatments are possible in treated mares (Roelle & Ransom, 2009). Whether injection is by hand or via darting, GonaCon-Equine is associated with some degree of inflammation, swelling, and the potential for abscesses at the injection site (Baker et al., 2018). Swelling or local reactions at the injection site are generally expected to be minor in nature, but some may develop into draining abscesses. A more detailed discussion and literature review on the effects of GonaCon is in Appendix N.

Intrauterine Devices (IUDs)

Existing literature on the use of IUDs in horses allows for inferences about expected effects of any management alternatives that might include use of IUDs and support the apparent safety and efficacy of some types of IUDs for use in horses. IUDs are considered a temporary fertility control method that does not generally cause future sterility (Daels & Hughes, 1995). The genetic effects of use of IUDs are expected to be comparable to those expected from fertility control vaccine use, insofar as reversible fertility control treatments can temporarily reduce the fraction of fertile mares in a herd.

The 2013 National Research Council of the National Academies of Sciences report considered IUDs and suggested that research should test whether IUDs cause uterine inflammation and should also test how well IUDs stay in mares that live and breed with fertile stallions. A more recent study tested a Y-shaped IUD to determine retention rates and assess effects on uterine health; retention rates were greater than 75% for an 18-month period, and mares returned to good uterine health and reproductive capacity after removal of the IUDs (Holyoak et al., 2021). Available evidence indicates that flexible IUDs should be considered a reversible fertility control method for most mares. Soft or flexible IUDs (Gradil et al., 2019; Holyoak et al., 2021) may cause relatively less discomfort than hard IUDs (Daels & Hughes, 1995).

Insertion of an IUD can be a very rapid procedure, but it does require the mare to be temporarily restrained, such as in a squeeze chute. Wild mares receiving IUDs would be checked for pregnancy by a veterinarian, prior to insertion of an IUD. Pregnant mares would not receive an IUD. The IUD is inserted into the uterus using a thin, tubular applicator similar to a shielded culture tube, and would be inserted in a manner similar to that routinely used to obtain uterine cultures in domestic mares. The presence of an IUD in the uterus may, like a pregnancy, prevent the mare from coming back into estrus (Turner et al., 2015). However, some domestic mares did exhibit repeated estrus cycles during the time when they had IUDs (Killian et al., 2008; Gradil et al., 2019). Because IUDs may prolong the time between estrus, but still allow for some degree of estrus behavior, it could be surmised that treated mares would continue to engage in behaviors consistent with estrus, though perhaps at somewhat reduced frequency. A more detailed discussion and literature review on the effects of IUDs is in Appendix N.

Fertility Control Indirect Effects

One expected long-term, indirect effect on wild horses treated with fertility control, such as PZP vaccines, GonaCon, or IUDs would be an improvement in their overall health (Turner & Kirkpatrick, 2002). Many treated mares would not experience the biological stress of reproduction, foaling and lactation as frequently as untreated mares. The observable measure of improved health is higher body condition scores (Nuñez et al., 2010). After a treated mare returns to fertility, her future foals would be expected to be healthier overall and would benefit from improved nutritional quality in the mare's milk. This is particularly to be expected if there is an improvement in rangeland forage quality at the same time, due to reduced wild horse population size. Past application of fertility control has shown that the animal's overall health and body condition remains improved even after fertility resumes. Fertility control vaccine treatment may increase mare survival rates, leading to longer potential lifespan (Turner & Kirkpatrick, 2002; Ransom et al., 2014). Changes in lifespan and decreased foaling rates could combine to cause changes in overall age structure in a treated herd (Turner & Kirkpatrick, 2002; Roelle et al., 2010), with a greater prevalence of older mares in the herd (Gross, 2000). Observations of mares treated in past gathers showed that many of the treated mares were larger than, maintained higher body condition than, and had larger healthy foals than untreated mares. A more detailed discussion and literature review on the indirect effects of fertility control methods is in Appendix N.

Impacts of Alternative 3

In the short term, implementation of Alternative 3 would result in capturing fewer wild horses than would be captured in Alternative 1. Removals would follow current WH&B policy and guidelines. Alternative 3 would not involve fertility control; mares would not undergo the marginal additional stress of receiving fertility control injections or freeze marking and would foal at normal rates until the next gather is conducted. The post-gather sex ratio would be about 50:50 mares to studs or would slightly favor mares. This would be expected to result in fewer and smaller bachelor bands, increased reproduction on a proportional basis (per-mare) within the herd, and larger band sizes. However, in the long term, because annual growth rates would remain higher than under either alternative with fertility control application, a larger number of wild horses may need to be captured and removed from the range than under either Alternatives 1 or 2, with a greater total number of animals needing to be removed as excess animals than either of those alternatives (Appendix M).

Impacts Common to Alternatives 1, 2, and 3

For over 40 years, various impacts to wild horses as a result of gather activities have been observed. Under Alternatives 1, 2, and 3 impacts to wild horses would be both direct and indirect, occurring to both individual horses and burros and the population as a whole.

In any given gather, gather-related mortality averages only about 0.5%, which is very low when handling wild animals (Scasta, 2019). Approximately, another 0.6% of the captured animals could be humanely euthanized due to pre-existing conditions and in accordance with BLM policy (GAO, 2008; Scasta, 2019). These data affirm that the use of helicopters and motorized vehicles has proven to be a safe, humane, effective, and practical means for the gather and removal of excess wild horses and burros from the public lands. The BLM also avoids gathering wild horses and burros by helicopter during the 6 weeks prior to and following the peak foaling season (i.e., March 1 through June 30).

Impacts to Individual Horses

Individual, direct impacts to wild horses include the handling stress associated with the roundup, capture, sorting, handling, and transportation of the animals. The intensity of these impacts varies by individual and is indicated by behaviors ranging from nervous agitation to physical distress. When being herded to trap site corrals by the helicopter, injuries sustained by wild horses may include bruises, scrapes, or cuts to feet, legs, face, or body from rocks, brush, or tree limbs. Rarely, wild horses encounter barbed wire fences and may receive wire cuts. These injuries are very rarely fatal and are treated on-site until a veterinarian can examine the animal and determine if additional treatment is indicated.

Other injuries may occur after a horse has been captured and is either within the trap site corral, the temporary holding corral, during transport between facilities, or during sorting and handling. Occasionally, horses may sustain spinal injuries or fractured limbs but based on prior gather statistics, serious injuries requiring humane euthanasia occur in less than one horse per every 100 captured. Similar injuries could be sustained if wild horses were captured through bait and/or water trapping, as the animals still need to be sorted, aged, transported, and otherwise handled following their capture. These injuries result from kicks and bites, or from collisions with corral panels or gates. After being gathered, horses would be under supervision of a given facility's attending veterinarian(s), who would monitor animal health including evidence of infectious disease.

To minimize the potential for injuries from fighting, the animals are transported from the trap site to the temporary holding facility where they are sorted as quickly and safely as possible, then moved into large holding pens where they are provided with hay and water. On many gathers, no wild horses are injured or die. On some gathers, due to the temperament of the horses, they are not as calm, and injuries are more frequent. Overall, direct gather-related mortality averages less than 1% (Scasta, 2019).

Indirect individual impacts are those which occur to individual wild horses after the initial event. These may include miscarriages in mares, increased social displacement, and conflict between males. These impacts, like direct individual impacts, are known to occur intermittently during wild horse gather operations. An example of an indirect individual impact would be the brief 1-to-2-minute skirmish between older studs which ends when one stud retreats. Injuries typically involve a bite or kick with bruises which do not break the skin. Like direct individual impacts, the frequency of these impacts varies with the population and the individual. Observations following capture indicate the rate of miscarriage varies but can occur in about 1 to 5% of the captured mares, particularly if the mares are in very thin body condition or in poor health.

A few foals may be orphaned during a gather such as if the mare rejects the foal, the foal becomes separated from its mother and cannot be matched up following sorting, the mare dies or must be humanely euthanized during the gather, the foal is ill or weak and needs immediate care that requires removal from the mother, or the mother does not produce enough milk to support the foal. On occasion, foals are gathered that were previously orphaned on the range (prior to the gather) because the mother rejected it or died. These foals may be in poor, unthrifty condition. Every effort is made to provide appropriate care to orphan foals. Veterinarians may administer electrolyte solutions or orphan foals may be fed milk replacer as needed to support their nutritional needs. Orphan foals may be placed in a foster home in order to receive additional care. Despite these efforts, some orphan foals may die or be humanely euthanized if the prognosis for survival is very poor. However, overall foal survival on the range is high, with a 5% or less mortality rate (King et al., 2023). Additionally, King et al. (2023) found that all orphaned or separated foals have a high survival rate, with all foals that were orphaned or separated in this study surviving.

In some areas, gathering wild horses during the winter may avoid the heat stress that could be associated with a summer gather. By fall and winter, foals are of larger body size and sufficient age to be weaned. Winter gathers are often preferred when terrain and higher elevations make it difficult to gather wild horses during the summer months. Under winter conditions, horses and burros are often located in lower elevations due to snow cover at higher elevations. This typically makes the horses closer to the potential trap sites and reduces the potential for fatigue and stress. While deep snow can tire horses as they are moved to the trap, helicopter pilots allow the horses and burros to travel slowly at their own pace. Trails in the snow are often followed to make it easier for horses to travel to the trap site. On occasion, trails can be plowed in the snow to facilitate the safe and humane movement of horses and burros to a trap. Wild horses may be able to travel farther and over terrain that is more difficult during the winter, even if snow does not cover the ground.

Water requirements are lower during the winter months, making distress from heat exhaustion extremely rare. By comparison, during summer gathers, wild horses may travel long distances between water and forage and become more easily dehydrated.

Through the capture and sorting process, wild horses are examined for health, injury, and other defects. Decisions to humanely euthanize animals in field situations would be made in conformance with BLM policy. The BLM Euthanasia Policy IM-2021-007 is used as a guide to determine if animals meet the criteria and should be euthanized. Animals that are euthanized for non-gather related reasons include those with old injuries (broken or deformed limbs) that cause lameness or prevent the animal from being able to maintain an acceptable body condition (greater than or equal to BCS 3); old animals that have serious dental abnormalities or severely worn teeth and are not expected to maintain an acceptable body condition, and wild horses that have serious physical defects such as club feet, severe limb deformities, or sway back. Some of these conditions have a causal genetic component and the animals should not be returned to the range to prevent suffering, as well as to avoid amplifying the incidence of the problem in the population.

Wild horses not captured may be temporarily disturbed and moved into another area during the gather operation. With the exception of changes to herd demographics from removals, direct population impacts have proven to be temporary in nature with most, if not all, impacts disappearing within hours to several days of release. No observable effects associated with these impacts would be expected within one month of release, except for a heightened awareness of human presence.

It is not expected that genetic diversity in any of these HMAs would be adversely impacted by the action alternatives. The AML range of 134 - 195 horses in the HMAs should provide for acceptable genetic diversity and would be monitored with further genetic sampling (see Appendix L). As explained above, existing levels of genetic diversity in each HMA have been adequate, under management conditions that include attempting to keep herd size in each HMA at its respective AML. Genetic diversity would be monitored with respect to observed heterozygosity at the scale of each HMA (Ho; BLM, 2010). Genetic monitoring would inform the BLM as to whether or not genetic diversity, as measured by observed heterozygosity (Ho), is acceptable, or whether any mitigating actions would need to be taken (BLM, 2010). If monitoring of observed heterozygosity levels, as measured from genetic monitoring samples, gives indication that genetic diversity should be increased in any single HMA or HMAs, the BLM would consider introducing animals to the herd in that HMA to increase local genetic diversity.

Returning wild horse populations sizes to AML in each of the HMAs of this would lower the density of wild horses across the HMAs, reducing competition for resources and allowing wild horses to utilize their preferred habitat. Maintaining population size within the established AML would be expected to improve forage quantity and quality and promote healthy, self-sustaining populations of wild horses in a thriving natural ecological balance and multiple use relationship on the public lands in the area. Relative to the ecological conditions associated with currently high wild horse herd sizes, further deterioration of the range associated with wild horse overpopulation would be minimized or reversed. Managing wild horse populations in balance with the available habitat and other multiple uses would lessen the potential for individual animals or the herd to be affected by drought and would avoid or minimize the need for emergency gathers, which would reduce stress to the animals and increase the success of these herds over the long-term.

Transport, Off-Range Corral (ORC) Holding, and Adoption (or Sale) Preparation

During transport, potential impacts to individual horses can include stress, as well as slipping, falling, kicking, biting, or being stepped on by another animal. Unless wild horses are in extremely poor condition, it is rare for an animal to be seriously injured or die during transport. During the preparation process for sale or adoption (e.g., freeze marking, blood samples, vaccination), potential impacts to wild horses are similar to those that can occur during handling and transportation. Serious injuries and deaths from injuries during the preparation process are rare but can occur.

At ORCs, a minimum of 700 square feet is provided per animal. Mortality at ORCs averages approximately 5% per year (GAO, 2008), and includes animals euthanized due to a pre-existing condition; animals in extremely poor condition; animals that are injured and would not recover; animals which are unable to transition to feed; and animals which are seriously injured or accidentally die during sorting, handling, or preparation. In ORCs, horses would be under supervision of a given facility's attending veterinarian(s), who would monitor animal health and signs of infectious disease.

Adoption or Sale with Limitations and Off-Range Pastures (ORP)
Potential impacts to wild horses from transport to adoption, sale, or ORP are similar to those previously described. One difference is that when shipping wild horses for adoption, sale or ORP, animals may be transported for a maximum of 24 hours. Immediately prior to transportation, and after every 18 to 24 hours of transportation, animals are offloaded and provided a minimum of 8 hours on-the-ground rest. During the rest period, each animal is provided access to unlimited amounts of clean water and 25 pounds of good quality hay per horse with adequate bunk space to allow all animals to eat at one time. Most animals are not shipped more than 18 hours before they are rested. The rest period may be waived in situations where the travel time exceeds the 24-hour limit by just a few hours and the stress of offloading and reloading is likely to be greater than the stress involved in the additional period of uninterrupted travel.

ORPs are designed to provide excess wild horses with humane, life-long care in a natural setting off the public rangelands. Animals are segregated into separate pastures by sex except one facility where geldings and mares coexist. Although the animals are placed in ORP, they remain available for adoption or sale to qualified individuals. No reproduction occurs in the ORP, but foals born to pregnant mares are gathered and weaned when they reach about 8 to10 months of age and are then shipped to ORCs where they are made available adoption. Handling by humans is minimized to the extent possible although regular on-the-ground observation and weekly counts of the wild horses to ascertain their numbers, well-being, and safety are conducted. A very small percentage of the animals may be humanely euthanized if they are in very thin condition and are not expected to improve to a BCS of three or greater due to age or other factors. Natural mortality of wild horses in ORP pastures averages approximately 8% per year but can be higher or lower depending on the average age of the horses pastured there (GAO, 2008).

Euthanasia
Decisions to humanely euthanize animals would be made in conformance with BLM policy (PIM 2021-007 or most current edition). Conditions requiring humane euthanasia occur infrequently and are described in more detail in PIM 2015-070: https://www.blm.gov/policy/pim-2021-007.

Impacts of Alternative 4 (No Action)
Under Alternative 4, there would be no active management to control the population size within the established AML at this time. In the absence of a gather, wild horse populations would continue to grow. Without gather and removal now, the wild horse population could reach 3,000 wild horses within 10 years, which is based upon the *PopEquus* results using the current estimated population (Appendix M).

Use by wild horses would continue to exceed the amount of forage allocated for their use. Competition between wildlife, livestock and wild horses for limited forage and water resources would continue. Damage to rangeland resources would continue or increase. Over time, the potential risks to the health of individual horses would increase, and the need for emergency removals to prevent their death from starvation or thirst would also increase. Over the long-term, the health and sustainability of the wild horse population is dependent upon achieving a thriving natural ecological balance and sustaining healthy rangelands. Allowing wild horses to die of dehydration or starvation would be inhumane and would be contrary to the Wild Horse and Burro Act which requires that excess wild horses be immediately removed when necessary to achieve a thriving natural ecological balance. Allowing rangeland damage to continue to result from wild horse overpopulation would also be contrary to the Wild Horse and Burro Act which requires the BLM to "protect the range from the deterioration associated with overpopulation", "remove excess animals from the range so as to achieve appropriate management levels", and "to preserve and maintain a thriving natural ecological balance and multiple-use relationship in that area."

3.2.7 Wilderness Study Areas

Affected Environment

Approximately 7,956 acres of the Buffalo Hills Wilderness Study Area (WSA) occurs within the south end of the Buckhorn HMA. The South Warner Wilderness Area is northeast of the Coppersmith HMA. There are no WSAs in the Carter Reservoir HMA. There are no wilderness areas, or other special designated areas in these three HMAs.

WSAs are managed to ensure they are unimpaired for preservation as wilderness until Congress has determined to designate them as wilderness or release them from WSA status. FLPMA recognizes special features of the public lands suitable for designation of a WSA: Roadless Areas over 5,000 acres , such as naturalness "…appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable….", outstanding opportunities"...has outstanding opportunities for solitude or a primitive and unconfined type of recreation, and other features"…may also contain ecological, geological, scientific, educational, scenic, or historical value."

All BLM lands, including those in the project area, were inventoried for wilderness characteristics in 1979 as required under the Federal Land Policy and Management Act of 1976 (FLPMA). Under section 603 of FLPMA, lands found to have wilderness characteristics in the original 1979 inventory were designated as Wilderness Study Areas (WSAs). WSAs that met the criteria and are within the project area include Wall Canyon and Massacre Rim. Sec. 603. [43 U.S.C. 1782] (a)

No off-road driving is anticipated. However, areas would be needed to back truck and trailers around, parking areas, and holding corrals-these areas could encompass 1-2 acres of landscape. Helicopters would be used for horse gathers, but no landings in WSAs are permissible, except in emergency situations.
BLM Manual 6330—Management of BLM Wilderness Study Areas Guidelines for Wildhorse and Burro management

Protect or enhance wilderness characteristics or values, as described in section 1.6.A.2 of BLM manual 6330, and Section 2(c) of the Wilderness Act of 1964 outlines the characteristics required of every wilderness. Actions that clearly benefit a WSA by protecting or enhancing these characteristics are allowable even if they are impairing, though they must still be carried out in the manner that is least disturbing to the site.

Wild horses and burros are managed to remain in balance with the productive capacity of the habitat; this includes managing herds so as not to impair wilderness characteristics. Wildhorse and burro populations must be managed at appropriate management levels so as to not exceed the productive capacity of the habitat (as determined by available science and monitoring activities), to ensure a thriving natural ecological balance, and to prevent impairment of wilderness characteristics, watershed function, and ecological processes.

Temporary traps may be located within WSAs for the effective removal of animals in excess of the appropriate management level. Traps must be situated to minimize impacts to vegetation and soils. Vehicles necessary for set-up and take-down of traps and for transporting excess wild horses and burros away from the area may be driven off of existing primitive routes or boundary roads on a route specified through the NEPA analysis. At the completion of the gather, all facilities must be removed, the route used for trap access closed to motor vehicles until it is restored to the original condition, and any new access route and trap area rehabilitated so that the route is no longer visible to subsequent motor vehicle operators.

The only WSA within the HMAs is the Buffalo Hills WSA at the southernmost extent of the Buckhorn HMA.

Impacts Common to Action Alternatives 1, 2, and 3

The Proposed Action and alternatives would on a temporary short-term basis negatively impact WSA values during gather activities, and throughout the indefinite duration of this proposal. The alternatives would impact visitors to the WSA as a result of the presence and noise of the helicopter, diesel trucks, other vehicles, staff personnel, and spectators for the duration of the gather. The alternatives are aimed at the removal of excess WH&Bs to reduce their population to the low-level AML in the Buffalo Hills WSA(CA-020-619). Managing the WH&B population to appropriate AML would be a positive long-term benefit to the natural character of the wilderness study areas; as it is expected to result in a healthy herd level and reduce negative impacts to the landscape from high numbers of WH&Bs. Excess WH&Bs compete with native populations of wildlife, overgraze riparian areas, and trample and denude native vegetation near springs and other water sources. Watchable wildlife values in the WSAs would be enhanced with fewer WH&Bs, although WH&B enthusiasts would have a minor negative impact for WH&B watching with fewer animals in the HMAs. Motorized vehicles would use the trails, roads, and ways within the WSAs, which would result in higher use than normal, which in turn could cause some erosion and impacts from excess dust. There would be moderate impacts to the WSAs at trap sites, from surface disturbing activities which would be limited to trampled vegetation and soils where diesel trucks/horse trailers would turn around. Trampled vegetation and soils would also occur at the wings and trap site from the horses and burros. There would be no landing of aircraft within the WSA, except for emergency situations, therefore no impacts from aircraft except for noise and presence. There would be temporary impacts to visual resources and the WSA recreation experience at the trap sites and surrounding area, due to the metal fence posts and jute fencing, which would be removed once the AML is reached. The character of the wilderness study areas would have temporary impacts, but no long-term negative impacts once the gather activities are complete.

Overall, the removal of excess wild horses from the WSAs would result in long term benefits to the natural type character of the landscape, by reducing the damage to native plant communities and water sources from overgrazing and excessive trampling. Watchable wildlife and hunting activities would have moderate benefits long term. The WSA guidelines in Manual 6330 allows for new disturbance if that action would provide long term benefits to the WSA (BLM, 2012).

Impacts of Alternative 4 (No Action)

The No Action Alternative would have no direct impacts from gather operations. However, the WSA experience would continue to deteriorate from excess wild horses and burros and have greater negative impacts overtime with higher numbers of WH&Bs. There would be no new impacts from construction of new facilities or surface disturbance from the new proposed Preferred and Alternative Trap sites in the Buffalo Hills WSA.

3.2.8 Wildlife

Affected Environment

Threatened and Endangered Species

On June 13, 2023, the US Fish and Wildlife Service Information for Planning and Consultation (IPaC) database was queried to determine if the Proposed Action would impact federally listed threatened or endangered species or have impacts on designated critical habitat for these species. The proposed project area was reviewed and there are no federally listed threatened or endangered species or designated critical habitat within the proposed project area. Therefore, these species are not discussed further in this EA.

BLM Special Status Species
BLM Policy under BLM Manual 6840 (Management of Special Status Species) requires that state-listed species receive the same level of protection afforded to ESA candidate species or the level of protection provided by state law – whichever would most effectively conserve the species (BLM, 2008b). BLM Special Status Species that may utilize the HMA for foraging and/or nesting habitat include greater sage-grouse (*Centrocercus urophasianus*) and golden eagle (*Aquila chrysaetos*).

Greater sage-grouse
As the name implies, this species is heavily dependent on sagebrush habitats, and is considered a sagebrush-obligate species. Greater sage-grouse are a landscape-scale species that are seasonally mobile and annually have a large home range (Stiver et al., 2006). Historical and active breeding strutting grounds (known as leks) on BLM-administered lands are located primarily in open, low sagebrush habitats. Sage-grouse use sagebrush stands as both winter and nesting habitat, with leks often located in open areas surrounded by sagebrush (Connelly et al., 2000). Sage-grouse most often nest under sagebrush shrubs, and successful nesting habitat contains tall grass cover (Gregg et al., 1994) in association with this sagebrush. Although many nests have been found in lower quality habitats (e.g., rabbitbrush-dominated habitats or habitats that lack perennial grasses and nesting cover), these are typically unsuccessful due to nest abandonment and predation. Early brood-rearing habitat consists generally of upland sagebrush sites relatively close to nest sites, typically characterized by high species richness, with an abundance of forbs and insects. Sage-grouse raise their broods in wet meadow and riparian habitats, where the young can forage on the abundant insects that are a critical component to their diet during their first few weeks of life (Schroeder et al., 1999). Hens typically move their chicks to more mesic conditions, such as higher elevation sagebrush communities, wet meadow complexes, or agricultural fields. Chick recruitment is diminished in areas lacking an abundance of succulent vegetation or available clean water. Specific factors that have been known to limit population expansion of greater sage-grouse include loss of vegetation cover, degradation of riparian areas, and degradation of wet meadows. Degradation of riparian and wetland habitats from continuous use by excess wild horses and burros is one reason these birds are at risk. The presence of wild horses is associated with a reduced degree of greater sage-grouse lekking behavior (Muñoz et al., 2020). Moreover, increasing densities of wild horses, measured as a percentage above AML, are associated with decreasing greater sage-grouse population sizes, measured by lek counts (Coates, 2021).

The gather area for the HMAs falls within the boundary of the Buffalo-Skedaddle, Massacre and Vya greater sage-grouse population management units. This area includes lands classified as Priority Habitat Management Areas (PHMAs), General Habitat Management Areas (GHMAs), Other Habitat Management Areas (OHMAs), and unclassified (typically non-habitat). PHMAs are defined as BLM-administered lands identified as the highest value to maintaining sustainable greater sage-grouse populations. GHMAs are BLM-administered lands where special management would apply to sustain greater sage-grouse populations in adjacent areas. OHMAs are BLM-administered lands identified as unmapped habitat within the planning area and contain seasonal or connectivity habitat areas (BLM, 2015).

In the ARMPA, Special Status Species (SSS) Management Decision (MD) 2D states that seasonal restrictions would be applied during the period specified below to manage discretionary surface-disturbing activities and uses on public lands (i.e., anthropogenic disturbances) that are disruptive to greater sage-grouse to prevent disturbances to greater sage-grouse during seasonal life-cycle periods. The following seasonal restrictions (SSS MD 2-D; ARMPA) would be applied to avoid disturbance to greater sage-grouse:

1. In breeding habitat within four miles of active and pending greater sage-grouse leks from March 1 through June 30

   a. Lek - March 1 to May 15
   b. Lek hourly restrictions - 6 p.m. to 9 a.m.
   c. Nesting - April 1 to June 30

2. Brood-rearing habitat from May 15 to September 15
   a. Early - May 15 to June 15
   b. Late - June 15 to September 15

3. Winter habitat from November 1 to February 28

Golden eagle
Golden eagles are a species of high public interest and are given consideration when planning resource activities. The golden eagle is designated a BLM sensitive species and is protected under the Migratory Bird Treaty Act of 1918 and the Bald and Golden Eagle Protection Act of 1940. Numerous golden eagle nest sites occur in the Applegate Field Office and the species is present within all watersheds. Currently, it is unknown how many of the known golden eagle nests are occupied; additional occupied nests could likely be found with additional survey effort. Management for this species is restricted to applying limited operating periods during the nesting season around known active nests. Although the golden eagle population trend in the Applegate Field Office is unknown, there is no evidence of decline.

Migratory Birds
Migratory bird means any bird listed in 50 CFR 10.13. All native birds commonly found in the United States, with the exception of native resident game birds, are protected under the Migratory Bird Treaty Act (MBTA) of 1918, as amended (16 U.S.C. 703 *et seq*.). The MBTA prohibits taking of migratory birds, their parts, nests, eggs, and nestlings without a permit. Executive Order 13186 directs federal agencies to protect migratory birds by integrating bird conservation principles, measures, and practices.

Numerous species of migratory birds use habitat within the HMA for food, cover, and nesting. Most of these species require diverse plant structure and herbaceous understory. Some species (e.g., western scrub jay, juniper titmouse, Oregon junco) primarily use trees, some other species (e.g., western meadowlark, Brewer’s sparrow, sage thrasher, sage sparrow) use sagebrush and other shrub species, and some nest on the ground. Woodland plants, such as western juniper, provide nesting and foraging habitat for many species. Riparian areas, such as those found within the HMA, serve as important transition habitats for a variety of species between seasons and are often heavily used during summer months. Additionally, riparian areas with woody species are important habitats for some migratory bird species as they provide important foraging and nesting habitats and are at risk for degradation due to yearlong continued use by wild horses and burros.

Sections 3.23 and 4.22 of the Surprise RMP (BLM, 2008a) provides additional information on wildlife resources within the Applegate Field Office resource area. These sections are incorporated by reference and describe Affected Environment and Environmental Consequences for wildlife within the Applegate Field Office resource area.

Impacts Common to Action Alternatives 1, 2, and 3
Direct short-term impacts from gather activities include disturbance to wildlife from the presence of people, vehicles, helicopters and wild horses and burros at the trap locations and temporary holding facilities during gather operations. Ground-nesting avian species such as the greater sage-grouse and northern harrier, and ground-dwelling terrestrial species including badger, burrowing owl, and ground squirrel, could experience loss of nests, damage to burrows, injury, or mortality to individuals or their young. Impacts to greater sage-grouse would be minimized, as no trap sites would be set up within a four-mile buffer of active and/or pending greater sage-grouse leks during the lekking and nesting seasons in areas of documented use determined by telemetry locations. Areas within a four-mile buffer of active and/or pending leks would be

considered avoidance areas and protect approximately 85% of nesting greater sage-grouse. Additionally, no trap sites would be set up in proximity to known populations of other sensitive species. Short- and long-term indirect impacts include reduced competition between wild horses and wildlife for forage and water due to an increase in the quality and quantity of available forage and water. Alternative 1, 2 and 3 would allow wildlife habitats to recover and improve the quality of habitats for most wildlife species in the long term.

Implementation of Alternatives 1, 2 and 3 would provide the greatest benefit to wildlife. The habitat would be able to recover and improve, and there would be less competition for resources between wild horse and wildlife populations. Specifically, shrub, native grass, total plant cover and species richness would increase, and invasive species would decrease (Beever et al., 2003; 2008). Riparian areas and meadow function would also improve as well as their associated perennial grasses and forbs – all of which would increase nest and brood survival of greater sage-grouse (Doherty et al., 2014) and other species, increase hiding cover, and result in the overall improvement of habitat quality for wildlife species. Reducing wild horse density to AML is associated with increasing greater sage-grouse population trends (Coates, 2021). Alternatives 1, 2, and 3 would also make progress towards meeting or making progress towards greater sage-grouse habitat objectives as outlined in Table 2-2 of the ARMPA. See Chapter 5 for design features that would be applied to be consistent with the ARMPA.

Impacts of Alternative 4 (No Action)

The direct impacts of this alternative would eliminate the short-term impacts from gather activities including disturbance to wildlife from the presence of people, vehicles, helicopters and wild horses and burros at the trap locations and temporary holding facilities during gather operations. Ground-nesting avian species such as the greater sage-grouse and northern harrier, and ground-dwelling terrestrial species including badger, burrowing owl, and ground squirrel, would not experience loss of nests, damage to burrows or habitat, and injury or mortality to individuals or their young would not occur.

Indirect impacts from this alternative would be the continued degradation to wildlife habitats including reduced quantity and quality of vegetation and degradation of riparian, meadows, and water resources necessary for wildlife. In the long term, this alternative would result in fewer plant species, lower the occurrence of native grasses, increase the presence of invasive species, and decrease vegetative cover (Beever & Aldridge, 2011); all of which would result in a decrease in nesting and brood survival of greater sage-grouse (Doherty et al., 2014) and other species. This alternative would also increase predation of wildlife species by reducing hiding cover. Alternative 4 would not conform to the ARMPA by not managing greater sage-grouse habitat within established AML ranges to achieve and maintain greater sage-grouse habitat objectives outline in Table 2-2 (Management Decision WH&B 2).

3.2.9 Vegetation

Affected Environment

Maintaining a balance of grazing animals and controlling the timing and amount of forage that is consumed each year by wildlife, livestock, and wild horses is crucial to maintaining healthy upland plant communities within the HMAs. Heavy grazing on the upland vegetation from excess wild horses does not allow upland sites to recover from past disturbances and those areas are in danger of trending downward in ecological health. The 2009 Buckhorn, Coppersmith, and Carter Reservoir Wild Horse Herd Management Areas Capture and Remove Plan EA (pages 22 to 27) has a more complete description of the upland vegetation.

Plant communities and sagebrush ecosystems that have been impacted in the past by wildfires and historic livestock grazing are vulnerable to losing more of their native perennial grass component when grazed at higher than moderate utilization levels (less than 60%) (USFS, 2017). Wild horses eat and spread viable seeds of cheatgrass, which can germinate in their feces (King et al., 2019). Sites that are close to crossing an ecological successional threshold to annual species and sites that are adjacent to water sources are the most vulnerable. Increased amounts of grazing on the uplands from an excess number of wild horses and burros does not allow some upland sites to obtain the amount of rest needed to recover from past disturbances.

Impacts of Action Alternatives 1, 2, and 3

Under Alternatives 1, 2, and 3, numbers of wild horses would be reduced, and maintained at AML, which would result in decreased impacts to vegetation throughout the HMAs. While removal of excess wild horses may not be able to restore plant communities that have crossed ecological thresholds to annual grass dominated communities, having the number of horses in the HMAs within AML and within HMAs would help prevent areas dominated by annual grass species from spreading. The removal of grazing pressure from excessive numbers of wild horses would lessen the impacts to perennial grasses, thus allowing them to better recover from natural disturbances such as fire, and to compete with non-native annual grasses such as cheatgrass and medusahead.

There would be some short-term direct effects to the vegetation within the gather sites and temporary holding facilities. Each of the gather sites is expected to be used for only a short duration (1 to 10 days) and at a level of use where effects would be short-term. Holding sites would be used for 1 to 30 days. In all trap and holding sites, vegetation is expected to be trampled by the animals with some plants likely becoming uprooted. Annual vegetation would have already senesced for the season, so the effects would be greater to the perennial species, such as bunchgrasses and shrubs. This short-term effect is outweighed, however, by reducing the long-term impacts to vegetation over the much larger area of the entire HMAs from heavy grazing by high numbers of horses (above AML) on the upland vegetation within and outside the HMAs.

Impacts of Alternative 4

Implementation of Alternative 4 would result in a continued increase in the number of wild horses above AML, which would have compounding impacts upon upland vegetation. Impacts would be seen first in sites that are already close to crossing an ecological successional threshold, or on sites that are near water sources. The increased grazing pressure from horse numbers in excess of the high AML range would result in a decrease in native perennial species, and an increase in non-native annual species (e.g., cheatgrass) or shrubs tolerant of disturbance (e.g., rabbitbrush) that have lower forage value and provide fewer ecosystem goods and services (Chambers et al., 2014). These changes would decrease the stability, biodiversity, vigor, and production of native plant communities within the HMAs.

4.0 Cumulative Impacts

4.1 Introduction

The National Environmental Protection Act (NEPA) regulations define cumulative impacts as impacts on the environment that result from the incremental impact of the Proposed Action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such actions (40 CFR 1508.7). Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. The cumulative impacts study area for the purposes of evaluating cumulative impacts in the HMAs and adjacent areas where horses have strayed outside the boundaries of the HMAs.

For the purposes of analyzing cumulative impacts on all affected resources, Section 4.2 describes the past, present, and reasonably foreseeable future relevant actions within the HMAs, while Section 4.3 describes the cumulative effects.

Public lands within the cumulative impact area have been typically used for animal grazing, transportation, energy transmission, and dispersed recreation. Additionally, fire has occurred within the cumulative impacts areas in the past and is expected to occur in the future. These activities are expected to continue in the future and no other site-specific applications have been received.

4.2 Past, Present, and Foreseeable Future Actions

4.2.1 Cultural Resources

Cultural resources, within the defined gather area of the HMAs and beyond, have historically and continue to be impacted by a range of often-overlapping natural and human-caused agents. These include, but are not limited to livestock grazing, wild horse grazing, range improvement projects, sage-steppe habitat and riparian improvement projects, wildland fires, and off-road travel and related recreational use of the landscape, as well as the erosion potential and ground disturbing nature each of these activities carry. Although many of these types of activities are occurring primarily on BLM-managed lands, similar actions, or activities on non-BLM federal or private lands have the potential to impact BLM-managed cultural resources as well. None of the grazing allotments included as part of the Proposed Action have been fully inventoried for cultural resources, so it is difficult to determine the full extent of cultural resource-related impacts without first understanding the extent of these resources more broadly.

Wildland fire frequency and intensity have increased more recently within the project area and at a landscape level, but wildland fire events have occurred across the HMAs and overlapping grazing allotments at regular intervals within the past half century. Given the propensity for wildland fires in the area, cultural resources likely have previously been exposed to wildland fire-related impacts at a landscape level. The heat from a fire can directly affect specific artifact types by causing heat damage and or burning fire-susceptible features and artifacts. Storms following fires can cause severe erosion through archaeological sites as well, resulting in the displacement of artifacts and potential destruction of specific feature types altogether. The lack of vegetation following a fire also exposes site surfaces, making them more visible to looters.

Looting, or the deliberate disturbance of cultural resources for purposes of illegal artifact collection, sometimes occurs but inadvertent actions from recreation, rock hounding, wood cutting, and other off-road activities are more common and affect cultural resources at higher rates and more significantly overall. Sage-steppe improvement projects, primarily related to juniper removal and/or reduction, also affect cultural resources resulting in similar landscape-level effects. Grazing by livestock, wild horses, and burros has probably affected a larger number of sites than have been documented and/or acknowledged to date through trailing, trampling, and shading/dusting activities. In areas where vegetation has been severely reduced or removed by overgrazing, erosion has also impacted cultural resources. Despite BLM and other stakeholder efforts to mitigate impacts to cultural resources through a variety of management strategies, predominately through avoidance, impacts are still occurring albeit at lower thresholds of significance, and these impacts are expected to continue moving forward despite best intentions and planning efforts; this is not to suggest that progress isn’t being made, but rather to acknowledge that cultural resource impacts are complex and that implementing potential solutions are likewise complicated and constantly evolving.

4.2.2 Fuels/Fire

Past and present fire history data, from 2000 through August 5, 2024, shows that there was a combined total of 54 wildfires that started within all three HMAs. Within the almost 24 years of history, 6 fires started within the Carter Reservoir HMA (Figure 4-1), 21 fires started within the Buckhorn HMA (Figure 4-2), and 27 fires started within the Coppersmith HMA (Figure 4-3). During the same period, a combined total of 29 fuel treatment projects occurred on the HMAs. Of those treatments, 2,045 acres were treated within the Carter Reservoir HMA, 1,127.84 acres were treated within the Buckhorn HMA, and 5,108 acres were treated within the Coppersmith HMA.

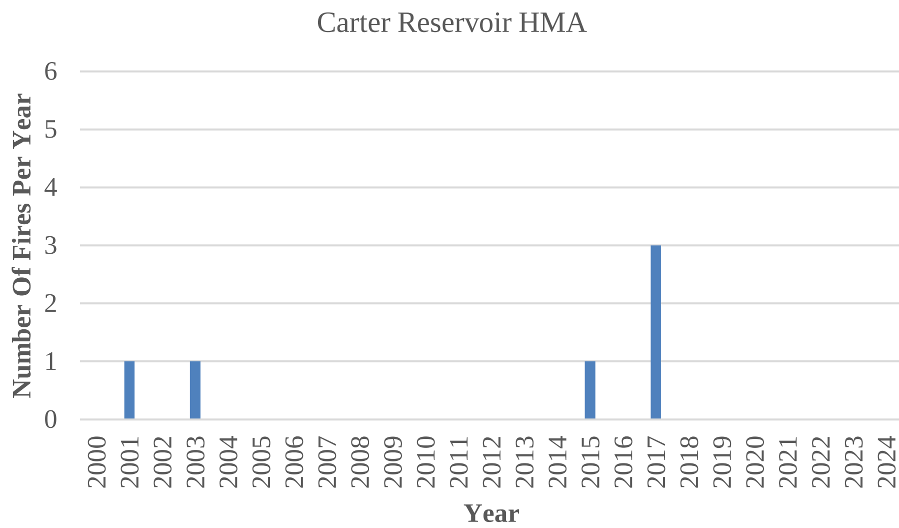

Figure 4-1. The total number of fires per year from 2000 through August 5, 2024, with starts in the Carter Reservoir Herd Management Area (HMA).

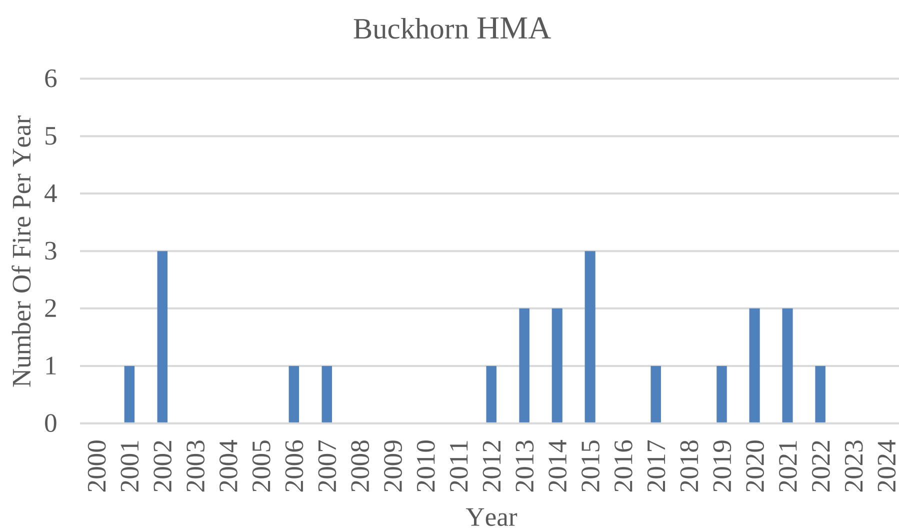

Figure 4-2. The total number of fires per year from 2000 through August 5, 2024, with starts in the Buckhorn Herd Management Area (HMA).

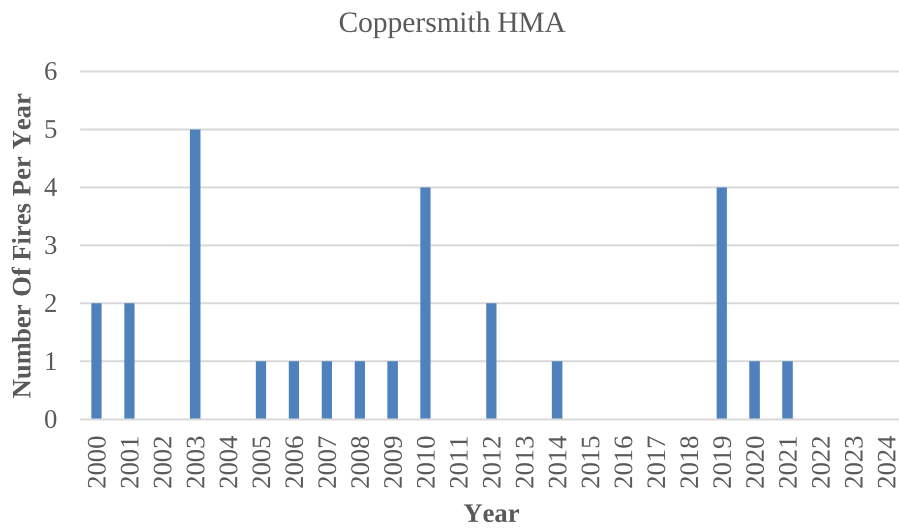

Figure 4-3. The total number of fires per year from 2000 through August 5, 2024, with starts in the Coppersmith Herd Management Area (HMA).

4.2.3 Livestock

Allotments within the HMAs have been grazed by livestock for more than 100 years. Excessive livestock grazing from the late 1800's to the 1930's altered plant composition and productivity on substantial portions of the lands currently managed by the Applegate Field Office. Livestock grazing management has been modified to reduce or eliminate impacts to vegetation and cultural sites through previous grazing decisions, which also resulted in adjustments to livestock numbers and seasons of use and for implementation of grazing systems and the associated range improvements to promote rangeland health.

Livestock grazing is expected to continue at similar stocking rates as those currently authorized. The BLM would continue to authorize permits that require livestock to be grazed under specific terms and conditions that are designed to achieve or make significant progress towards achieving Rangeland Health Standards.

4.2.4 Riparian Areas

Overpopulation of wild horses can have substantial impacts to rangeland resources, such as riparian areas (Crist et al., 2019). This has led to the degradation of riparian areas, and the growing overpopulation continues to degrade sensitive riparian areas and the associated vegetation. The BLM has repaired or newly constructed (i.e., fenced) approximately 16 riparian areas in the HMAs since 2010.

Ongoing restoration and rehabilitation efforts include restoring riparian and wet meadows through spring head development, off-site watering, and spring protection exclosures to increase cover, biodiversity, and function. Maintaining a balance of grazing animals and controlling the timing, intensity, and duration of grazing and amount of forage consumed each year by livestock and wild horses is crucial to maintaining healthy riparian plant communities for the future. One riparian area is planned for repair/restoration in the HMAs by the BLM.

4.2.5 Soil Resources

Site specific soil conditions have varied over the past 100 years within the HMAs. These variances in conditions can partially be attributed to various factors such as wild horse grazing, livestock grazing, off-road vehicle use, wildfire, and invasive species, among other things. The year-round disturbance of wild horses on the area, espcially during times of exceedingly high AML, has and can lead to soil degradation due to the heavy use in certain areas. However, if wild horse populations were to continue to increase in size in the HMAs, soil degradation could further degrade in both current problem sites, as well as in new locations. Degradation of soils could occur through various processes, such as a decrease in biological soil crusts, increase in erosion and/or compaction, and the loss of the overall vegetative cover. The removal of excess wild horses would significantly reduce, or even reverse, the long-term damage to soils resulting from the aforementioned processes.

4.2.6 Wild Horses and Burros

In years that the populations of wild horses have exceeded the established AML range, disturbance to vegetation and to cultural resource sites has occurred in some areas. Since 1976, the BLM has conducted numerous gathers of wild horses in different parts of the HMAs in order to remove excess animals to manage the population size within the established AML ranges. Gathering any wild animals into pens has the potential to cause impacts to individual animals. There is also the potential for impacts to individual horses and burros during transportation, short-term holding, or long-term holding that take place after a gather. However, BLM follows guidelines to minimize those impacts and ensure humane animal care and high standards of welfare. The following literature review summarizes the limited number of scientific papers and government reports that have examined the effects of gathers and holding on wild horses and burros.

Two early papers, by Hansen and Mosley (2000) and Ashley and Holcomb (2001), examined limited effects of gathers, including behavioral effects and effects on foaling rates. Hansen and Mosley (2000) observed BLM gathers in Idaho and Wyoming. They monitored wild horse behaviors before and after a gather event and compared the behavioral and reproductive outcomes for animals that were gathered by helicopter against those outcomes for animals that were not. This comparison led to the conclusion that gather activities used at that time had no effect on observed wild horse foraging or social behaviors, in terms of time spent resting, feeding, vigilant, traveling, or engaged in agonistic encounters (Hansen & Mosley, 2000). Similarly, the authors did not find any statistically significant difference in foaling rates in the year after the gather in comparisons between horses that were captured, those that were chased by a helicopter but evaded capture, or those that were not chased by a helicopter. The authors concluded that the gathers had no deleterious effects on behavior or reproduction. Ashley and Holcomb (2001) conducted observations of reproductive rates at Garfield Flat HMA in Nevada, where horses were gathered in 1993 and 1997, and compared those observations at Granite Range HMA in Nevada, where there was no gather. The authors found that the two gathers had a short-term effect on foaling rates; pregnant mares that were gathered had lower foaling rates than pregnant mares that were not gathered. The authors suggested that BLM make changes to the gather methods used at that time, to minimize the length of time that pregnant mares are held prior to their release back to the range. Since the publications by Hansen and Mosley (2000) and by Ashley and Holcomb (2001), BLM did make changes to reduce the stress that gathered animals, including pregnant females, may experience as a result of gather and removal activities; these measures have been formalized as policy in the comprehensive animal welfare program (BLM PIM 2021-002).

A thorough review of gather practices and their effects on wild horses and burros can be found in a 2008 report from the Government Accounting Office. The report found that the BLM had controls in place to help ensure the humane treatment of wild horses and burros (GAO, 2008). The controls are included in the gather section of the CAWP for gather operations, inspections, and data collection to monitor animal welfare. These procedures led to humane treatment during gathers, and in short-term and long-term holding facilities. The report found that cumulative effects associated with the capture and removal of excess wild horses include gather-related mortality averaged only about 0.5% and approximately 0.7% of the captured animals, on average, are humanely euthanized due to pre-existing conditions (such as lameness or club feet) in accordance with BLM policy. Scasta (2019) found the same overall mortality rate (1.2%) for BLM WH&B gathers in 2010-2019, with a mortality rate of 0.25% caused directly by the gather, and a mortality rate of 0.94% attributable to euthanasia of animals with pre-existing conditions such as blindness or club-footedness. Scasta (2019) summarized mortality rates from 70 BLM WH&B gathers across nine states, from 2010-2019. Records for 28,821 horses and 2,005 burros came from helicopter and bait/water trapping. For wild burro bait / water trapping, mortality rates were 0.05% due to acute injury caused by the gather process, and death for burros with pre-existing conditions was 0.2% (Scasta, 2019). For wild horse bait / water trapping, mortality rates were 0.3% due to acute injury, and the mortality rate due to pre-existing conditions was 1.4% (Scasta, 2019). For wild horses gathered with the help of helicopters, mortality rates were only slightly lower than for bait / water trapping, with 0.3% due to acute causes, and 0.8% due to pre-existing conditions (Scasta, 2019). Scasta (2019) noted that for other wildlife species capture operations, mortality rates above 2% are considered unacceptable and that, by that measure, BLM WH&B "…welfare is being optimized to a level acceptable across other animal handling disciplines."

The GAO report (2008) noted the precautions that BLM takes before gather operations, including screening potential gather sites for environmental and safety concerns, approving facility plans to ensure that there are no hazards to the animals there, and limiting the speeds that animals travel to trap sites.

In 2010, the American Association of Equine Practitioners (AAEP, 2011) was invited by the BLM to visit the BLM operations and facilities, spend time on WH&B gathers and evaluate the management of the wild equids. The AAEP Task Force evaluated horses in the BLM Wild Horse and Burro Program through several visits to wild horse gathers, and short- and long-term holding facilities. The task force was specifically asked to "review animal care and handling within the Wild Horse and Burro Program, and make whatever recommendations, if any, the Association feels may be indicated, and if possible, issue a public statement regarding the care and welfare of animals under BLM management." In their report (AAEP, 2011), the task force concluded "that the care, handling and management practices utilized by the agency are appropriate for this population of horses and generally support the safety, health status and welfare of the animals."

In June 2010, BLM invited independent observers organized by American Horse Protection Association (AHPA) to observe BLM gathers and document their findings. AHPA engaged four independent credentialed professionals who are academia-based equine veterinarians or equine specialists. Each observer served on a team of two and was tasked specifically to observe the care and handling of the animals for a 3-4-day period during the gather process and submit their findings to AHPA. An Evaluation Checklist was provided to each of the observers that included four sections: Gather Activities; Horse Handling During Gather; Horse Description; and Temporary Holding Facility. The independent group visited 3 separate gather operations and found that "BLM and contractors are responsible and concerned about the welfare of the horses before, during and after the gather process" and that "gentle and knowledgeable, used acceptable methods for moving horses… demonstrated the ability to review, assess and adapt procedures to ensure the care and well-being of the animals" (Greene et al., 2013).

BLM commissioned the Natural Resources Council of the National Academies of Sciences to conduct an independent, technical evaluation of the science, methodology, and technical decision-making approaches of the BLM Wild Horse and Burro Management Program. Among the conclusions of their 2013 report, NRC concluded that wild horse populations grow at 15 to 20% a year, and that predation would not typically control population growth rates of free-ranging horses. The report also noted that, because there are human-created barriers to dispersal and movement (i.e., fences and highways) and no substantial predator pressure, maintaining a herd within an AML requires removing animals in roundups, also known as gathers, and may require management actions that limit population growth rates (NRC, 2013) Additionally, the report examined a number of population growth suppression techniques, including the use of sterilization, fertility control vaccines, and sex ratio manipulation (NRC, 2013).

The effects of gathers as part of feral horse management have also been documented on National Park Service Lands. Since the 1980s, managers at Theodore Roosevelt National Park have used periodic gathers, removals, and auctions to maintain the feral horse herd size at a carrying capacity level of 50 to 90 horses (Amberg et al., 2014). In practical terms, this carrying capacity is equivalent to an AML. Horse herd sizes at those levels were determined to allow for maintenance of certain sensitive forage plant species. Gathers every 3-5 years did not prevent the herd from self-sustaining. That herd continues to grow, to the point that the NPS now uses gathers and removals along with temporary fertility control methods in its feral horse management (Amberg et al., 2014).

The excess animals removed have been transported to off-range corral (ORC) facilities where they were prepared for adoption, sale (with limitations), off-range pastures (ORP), or other statutorily authorized disposition. The GAO report (2008) noted that BLM used SOPs for short-term holding facilities (i.e., corrals) that included procedures to minimize excitement of the animals to prevent injury, separating horses by age, sex, and size, regular observation of the animals, and recording information about the animals in a BLM database. The GAO reported that BLM had regular inspections of short-term holding facilities and animals there, ensuring that the corral equipment is up to code and that animals are treated with appropriate veterinary care (including that hooves are trimmed adequately to prevent injury). Mortality was found to be about 5% per year associated with transportation, short-term holding, and adoption or sale with limitations. The GAO noted that BLM also had controls in place to ensure humane care at long-term holding facilities (i.e., pastures). BLM staff monitor the number of animals, the pasture conditions, winter feeding, and animal health. Veterinarians from the USDA Animal and Plant Health Inspection Service inspect long-term facilities annually, including a full count of animals, with written reports. Contract veterinarians provide animal care at long-term facilities, when needed. Weekly counts provide an incentive for contractors that operate long-term holding facilities to maintain animal health (GAO, 2008). Mortality at long-term holding was found to be about 8% per year, on average (GAO, 2008). The mortality rates at short-term and long-term holding facilities are in the range of natural annual mortality rates on the range, which varies by year and location but may average about 13-16% per year for foals (animals under age 1), about 5-10% per year for horses ages 1-10 years, and about 10-25% for animals aged 10-20 years (Garrott & Taylor, 1990; Ransom et al., 2016).

The last gather for the HMAs were conducted in 2009 when 523 horses were gathered with 23 mares treated and released along with 12 studs. All released animals were marked with a freeze mark prior to release for future identification. A post gather flight inventory was completed in 2010 resulting with an estimated 316 horses.

The current population within and outside the HMAs for 2023 is estimated 752 horses based off the 2022 flight inventories and the estimate of a 20% per year population growth rate for population projections leading to the 2023 estimate. The actions which have influenced today's wild horse population are primarily the lack of wild horse gathers, which have resulted in the increase of numbers due to decrease removal of excess wild horses, and release of treated mares back into the HMAs (see Appendix K for the historical gather and release record for the HMAs). Potential effects of fertility control methods are considered in Appendix N.

Continued wild horse grazing would likely occur. Over the next 10-to-20-year period, reasonably foreseeable future actions include gathers with a frequency of up to two years to remove excess wild horses and/or implement fertility controls in order to manage population size within the established AML range could occur. The excess animals removed would be transported to ORCs where they would be prepared for adoption, sale (with limitations), or long-term holding. A program with annual remotely delivered fertility control, or one in which remotely delivered fertility control is administered in conjunction with future gathers could also reduce population growth. There is the potential that some animals treated by fertility control methods approved by separate BLM administrative units (e.g., from Twin Peaks HMA) could move onto these lands; such animals may marginally reduce average fertility rates within the HMAs, but such effects are expected to be minimal. Any future wild horse management, aside from the proposed management actions specified in this EA, would be analyzed in appropriate environmental analysis/documentation following site-specific planning with public involvement.

4.2.7 Wilderness Study Areas

Wildfires, livestock grazing, livestock water facilities, wild horse, and burros, off road driving, and recreation are actions that have occurred within the wilderness study areas. Wildfires impact wilderness study area landscapes and vegetation composition. Livestock grazing, wild horses, and burros have the potential to impact vegetation composition and forage availability for wildlife and watchable wildlife values. Livestock water projects can affect the natural character of the area. Recreation also has the potential to impact the undeveloped areas that contribute to the WSA.

Wildfires, livestock grazing, wild horse and burro management, and recreation are reasonably foreseeable future actions that are expected to occur within the wilderness study areas. Wildfires have the potential to impact wilderness study area landscapes, vegetation composition, and visual resources. Livestock grazing and wild horses and burros have the potential to impact and alter vegetation composition and forage availability for high or special value wildlife. This in turn can affect the natural character of the area. Recreation activities, hunters, and special recreation permits have the potential to impact wilderness study area visitors. Trap sites alter the landscape on a temporary short-term basis for the WSA recreation experience.

4.2.8 Wildlife

Hunting for various wildlife species within and outside of the HMA occurs consistent with state wildlife laws and is managed by California Department of Fish and Wildlife (CDFW) and Nevada Department of Wildlife (NDOW). Forage allocations for livestock, wild horses, and wildlife have been established in the past by the BLM. Additionally, annual livestock numbers, seasons of use, and other factors in livestock grazing management have been implemented to improve rangeland and ecosystem health benefiting wildlife.

The ARMPA contains program area goals, objectives, and management decisions to strive to protect and preserve the greater sage-grouse and its habitat on BLM-administered lands that include the HMAs and its vicinity (see Table 2-2 of the ARMPA). Vegetation, livestock grazing, and wild horses are examples of these program areas. The BLM, along with NDOW and other partners, have also installed water catchments that benefit wildlife and may also be used at times by wild horses and livestock. Overpopulation of wild horses is increasing the habitat degradation of both vegetation and water resources within and outside of the HMAs and decreasing habitat quantity and quality for numerous wildlife species.

Wildlife habitat needs and hunting of game species would continue to occur in the HMAs. The ARMPA and its program area goals, objectives, and management decisions would continue to be implemented for the benefit of greater sage-grouse and other wildlife species. The BLM, NDOW and other partners would maintain and replace the water catchments that benefit wildlife and continue to implement projects to improve rangeland health and wildlife habitat. Reasonably foreseeable future actions also include greater sage-grouse lek counts, which would continue within the HMAs to assist in contributing to population data and to monitor habitat conditions.

4.2.9 Vegetation

While the current livestock grazing system and efforts to manage the wild horse population within the AML has reduced the potential of past historic impacts to occur, the current overpopulation of wild horses is continuing to contribute to areas of heavy vegetation use, trailing and trampling damage and is preventing the BLM from managing for rangeland health and a thriving natural ecological balance and multiple use relationship on BLM-administered lands in the area. Wild horses can have substantial impacts on rangeland resources, including vegetation (Crist et al., 2019). This overpopulation has degraded vegetation, and the growing overpopulation continues to degrade vegetation resources.

Additionally, numerous wildfires have occurred within the HMAs. These wildfires have influenced native vegetation and potentially affected cultural resources. There have been numerous seedings within the HMAs in response to wildland fires and past degradation. Past seedings include the use of both native and non-native plant species. Noxious weeds may also spread and increase post-wildfire. The BLM has conducted integrated weed management for over 25 years to monitor and treat infestations of noxious weeds and invasive species within the HMAs. Monitoring and treatments would continue into future years as outlined in the 2018 Applegate Integrated Weed Management Plan Programmatic Environmental Assessment (DOI-BLM-CA-N020-2017-0017-EA).

It is predicted that additional wildfires would occur in the future, and the lands affected may have emergency stabilization or rehabilitation efforts implemented on them. Future actions would likely be related to the effects from wildfires. Ongoing restoration and rehabilitation efforts include planting native shrubs and beneficial herbaceous species to increase cover, biodiversity, and function. This type of action also increases soil health and productivity. Planting vegetation would be the primary action to reduce wind and water soil erosion. Other actions could include juniper thinning and removing Phase I stands that are encroaching on sagebrush dominated rangelands. No new roads are expected to be built.
Livestock grazing is expected to continue at similar stocking rates and utilization of the available vegetation (forage) would also be expected to continue at similar levels. The BLM would continue to monitor and treat infestations of noxious weeds and invasive species in the HMAs using Integrated Weed Management.

4.3 Cumulative Effects

The cumulative impacts to these resources which would be expected to result with implementation of the Action Alternatives, or No Action Alternative are discussed in detail below.

4.3.1 Cultural Resources

Any ground disturbing activities can damage site function and integrity, thus the excessive overgrazing of uplands and riparian/wetland sites that would occur with Alternative 4, combined with past actions of wildfire and historic heavy livestock grazing, would likely cause some plant communities to become degraded to the point of crossing an ecological threshold. The resulting limited amount of plant litter and cover would afford little to no protection to cultural sites, resulting in potential loss and destruction of cultural resources and/or areas of Tribal significance through erosion, direct horse impacts (trampling, trailing, rolling, wallowing), and higher looting potential given higher site surface visibility and exposure. Riparian sites or wetlands which are still recovering from the damage caused by past heavy grazing use would likely become so damaged as to lose the entire structure, function, and integrity of the water source associated with these sites and also potentially significant to Tribes. Smaller riparian sites currently experiencing horse impacts and susceptible to increasing drought conditions would likely become nonfunctional and dry up, with a high amount of damage to cultural resources through breakage, displacement, and loss of site integrity as horses attempt to utilize these non-functional water sources through vertical and horizontal soil excavation. The gather and removal of excess wild horses as described in Alternatives 1, 2, and 3, would improve vegetation health, reduce direct horse impacts to sites and areas of Tribal significance, reduce future looting and erosion potential, and provide greater protection for cultural resources overall.

4.3.2 Fuels/Fire

Overall, the year-round nature of the grazing of wild horses reduces the volume of fuels and decreases the potential for wildfire, but in turn depletes and/or harms rangeland resources. Grazing of livestock can also impact various rangeland resources, but the difference is that when ecological and vegetative triggers are tripped, associated with the terms and conditions of livestock grazing permits, permittees are required to move or remove their livestock from the grazing allotment. While imperfect, the nimble tool of direct livestock grazing management is not analogous to the BLM’s management of wild horses. The BLM cannot actively manage wild horses’ movement on a day-to-day or even on a month-to-month basis. Thus, wild horses can actively graze year-round which has the potential to reduce the potential of wildfires, but in turn can harm rangeland resources and spread invasive species over a great distance. Implementing Alternatives 1, 2, and 3 and in turn maintaining the wild horse population numbers within AML, would in varying degrees decrease the long-term potential for new fire starts based on slowing the spread of fine fuels. Implementing Alternative 4 would result in a substantial increase in the wild horse population. While that may somewhat reduce the availability of fine fuels, it would increase the potential for fires by compounding the detrimental impacts of wild horses on upland vegetation composition.

4.3.3 Livestock

Through the land-use planning process and grazing permit renewal decisions, livestock grazing permits have been set at a level that balances forage resources between livestock and wild horses. The terms and conditions of livestock grazing permits are designed to allow forage resources to rest from grazing at various times of each year and to ensure that plants have adequate time for regrowth after grazing. When horse numbers become higher than the established AML, overall impacts to forage resources are higher, as more forage is consumed in the same time periods. This does not allow the livestock grazing systems to function as they have been designed, as no rest occurs on forage plants after livestock are removed from the allotment since they are continuously grazed by higher numbers of horses than the range can sustain.
By removing excess wild horses as described in Alternatives 1, 2, and 3, livestock operations and grazing systems would function properly, and forage plants would receive rest from grazing during scheduled rest periods. The health and condition of vegetation would be maintained, and plant communities that have been impacted by wildfires or past heavy livestock grazing would continue to improve in condition. Forage quality and production for livestock grazing would be expected to be maintained.

Implementation of Alternative 4 would result in substantial increases in wild horse numbers, and competition for forage and water would become more prevalent between livestock and horses. Plant communities that are still recovering from the effects of wildfires or past heavy livestock grazing would be the most vulnerable to further degradation. As wild horse and burro numbers increase, plant communities would experience a serious decline in condition, forage quality, and production. Forage resources for livestock would be highly degraded, and changes to grazing permits would most likely need to be made because of declining rangeland health.

4.3.4 Riparian Areas

The number of wild horses and burros in the HMAs have been above the established AML range for at least ten years. Data from 2018 through 2022 demonstrates that riparian/wetland sites, lotic and lentic sources, are being adversely impacted as a result of year-long wild horse use. By removing excess wild horses as described in Alternatives 1, 2, and 3, sites rated as "Functioning at Risk" would have the opportunity to recover and improve in condition, and no cumulative impacts are expected. Sites currently rated as "Proper Functioning Condition" would be able to maintain that condition.

Implementation of Alternative 4 would allow continued overpopulation of wild horses above the established AML range. Without a decrease in wild horse populations, it is likely the functional ratings of riparian areas would decrease, in some cases crossing irreparable ecological thresholds. Riparian areas that are recovering from past overgrazing could become de-watered (reversing improvements that have been made over time), as the vegetation converts from riparian dominated vegetation to upland species. If these changes occur, water sources would stay wetter for a shorter period of time and stand the chance of converting from surface flow (which serves as a water source for horses, livestock, and wildlife) to sub-surface flow that is unavailable for drinking water. This would increase impacts on remaining spring sources, as animals would concentrate in ever higher numbers on the remaining available drinking water sites.

4.3.5 Soil Resources

Cumulative effects to soils under Alternatives 1, 2, and 3 would be minimal and temporary. Some areas such as trap sites and holding facilities would experience some trampling and localized soil compaction, however these areas are generally small and make up less than 1% of the project area. Once animals are removed from these sites, soils are expected to recover within one growing season. Reducing the population of wild horses to within the established AML range under Alternatives 1, 2, and 3 could reduce the long-term damage to soils resulting from trampling, compaction, and overgrazing of vegetation.

Under Alternative 4, wild horse populations would continue to increase and upland sites would become overgrazed by horses resulting in the loss of vegetative cover and litter to protect the soil surface. There would also be a decrease in biological soil crusts and an increase in soil erosion and compaction. Sites currently dominated by annual and invasive grass species would become more degraded and eventually cross ecological thresholds. These degraded sites typically produce lower amounts of plant biomass and cover, are dominated by plants with shallow root systems, and provide little soil stability.

4.3.6 Wild Horses and Burros

Impacts Common to Action Alternatives (1, 2, and 3)

The cumulative effects associated with the capture and removal of excess wild horses includes gather-related mortality of less than 1% of the captured animals, about 5% per year associated with transportation, off-range corrals, adoption, or sale with limitations and about 8% per year associated with off-range pastures. This compares with natural mortality on the range, which varies by year and location but may average about 13 to 16% per year for foals (animals under age 1), about 5 to10% per year for horses ages 1 to 10, about 10 to 25% for animals aged 10 to 20 years, and about 25 to 50% for animals aged 20 to 25 years (Jenkins, 1996; Garrott & Taylor, 1990; Ransom et al., 2016). In situations where forage and/or water are limited, mortality rates increase, with the greatest impact to young foals, nursing mares and older horses. Animals can experience lameness associated with trailing to/from water and forage, foals may be orphaned (left behind) if they cannot keep up with their mare, or animals may become too weak to travel. However, King et al. (2023) concluded that, "…separation of offspring may be more common than previously considered, and that this is a natural event that does not necessarily result in mortality. … the separation of young foals from their dams was not a result of human disturbance or handling, resulting in the conclusion that foals even as young as 2 months old have a good chance of survival if separated from their dam or orphaned, as long as other social groups remain on the range that they can join." After suffering, often for an extended period, the animals may die. Before these conditions arise, the BLM generally removes the excess animals to prevent their suffering from dehydration or starvation.

While humane euthanasia and sale without limitation of healthy horses for which there is no adoption demand is authorized under the Wild Horse and Burro Act, Congress prohibited the use of appropriated funds between 1987 and 2004 and again since 2010 for this purpose.

The other cumulative effects which would be expected when incrementally adding either of the Action Alternatives would include continued improvement of upland vegetation conditions, which would in turn benefit permitted livestock, native wildlife, and wild horse and burro population as forage (habitat) quality and quantity is improved over the current level. Benefits from a reduced wild horse population would include fewer animals competing for limited forage and water resources. Cumulatively, there should be more stable wild horse populations, healthier rangelands, healthier wild horses, and fewer multiple use conflicts in the area over the short and long-term. Over the next 15 to 20 years, continuing to manage wild horses within the established AML range would achieve a thriving natural ecological balance and multiple use relationship on public lands in the area.

Cumulative Impacts of Alternative 1 (Proposed Action)

Application of fertility control and adjustment in sex ratios to favor males should slow population growth and result in fewer gathers and less frequent disturbance to individual wild horses and the herd's social structure. However, return of wild horses back into the HMAs could lead to decreased ability to effectively gather horses in the future as released horses learn to evade the helicopter.

Cumulative Impacts of Alternative 2

Application of fertility control would slow population growth and result in fewer gathers and less frequent disturbance to individual wild horses and the herd's social structure. However, return of wild horses back into the HMAs could lead to decreased ability to effectively gather horses in the future as released horses learn to evade the helicopter.

Cumulative Impacts of Alternative 4 (No Action)
Under the No Action Alternative, the wild horse population could reach or exceed 5,000 wild horses in ten years based on PopEquus modeling (Appendix M). Movement outside the HMAs and onto private lands and adjacent BLM lands (not managed by Applegate Field Office) would be expected as greater numbers of horses search for food and water for survival, thus impacting larger areas of public lands. Heavy to excessive utilization of the available forage would be expected and the water available for use could become increasingly limited. Eventually, ecological plant communities would be damaged to the extent that they are no longer sustainable or recoverable and the wild horse population would be expected to crash.

Emergency removals could be expected in order to prevent individual animals from suffering or death as a result of insufficient forage and water. These emergency removals could occur as early as the next drought and perennial water sources become dry early in the season. During emergency conditions, competition for the available forage and water increases. This competition generally impacts the oldest and youngest horses as well as lactating mares first. These groups would experience substantial weight loss and diminished health, which could lead to their prolonged suffering and eventual death. If emergency actions are not taken, the overall population could be affected by severely skewed sex ratios towards stallions as they are generally the strongest and healthiest portion of the population. An altered age structure would also be expected.

Cumulative impacts would result in foregoing the opportunity to improve rangeland health and to properly manage wild horses in balance with the available forage and water and other multiple uses. Attainment of site-specific vegetation management objectives and Standards for Rangeland Health would not be achieved. AML would not be achieved and the opportunity to collect the scientific data necessary to re-evaluate AML levels, in relationship to rangeland health standards, would be foregone.

4.3.7 Wilderness Study Areas
Past recreation activities have had minor short-term effects from unauthorized roads, campsites, and off-road driving. Wild horse and burro gathers have had short term impacts from vehicles, equipment, and trap locations. This area has not had a wild horse and burro gather for 14 years, which has allowed the natural character of the landscape to be negatively compromised and continue to decline over the years from excess WH&B numbers on the landscape. The highest level of deterioration is around springs, other water sources and upland vegetation. By removing excess wild horses and burros as described in Alternatives 1, 2, and 3, cumulative impacts to wilderness study areas are expected to benefit all values long-term but would have short term temporary impacts to the WSA experience during the gather phase from vehicles, helicopters, noise, and temporary facilities. With the removal of excess wild horses and burros, long term positive benefits would occur to the natural character of the landscape. This would not combine with any other reasonably foreseeable future actions to negatively impact long term wilderness characters that contribute to WSA status. There would be temporary and short-term direct impacts from construction of new facilities and surface disturbance from the new proposed Preferred and Alternative Trap sites in the Buffalo Hills WSA along the Buckhorn Back-Country-Byway Road.

Alternative 4 would result in the further degradation of riparian/wetland sites and the natural character of the wilderness study areas. Cumulative impacts to the WSAs under Alternative 4 are expected to have long-term continuing negative impacts on the natural character of the landscape. This would affect hunting and watchable wildlife values due to the continuing decline of the vegetation and water sources from the excessive use by WH&Bs.

4.3.8 Wildlife
Maintaining a balance of grazing animals and controlling the timing and amount of forage that is consumed

each year by livestock and wild horses is crucial to maintaining healthy upland plant communities that provide important wildlife forage and cover. By removing excess wild horses as described in Alternatives 1, 2, and 3, cumulative impacts to wildlife habitat are expected to be beneficial. Habitat enhancement projects, including the fencing of riparian and spring sites from livestock and wild horses, further improve habitat quality for greater sage-grouse and other wildlife.

Implementation of Alternative 4 would result in the further degradation of riparian/wetland sites. It is estimated that with the projected increase over the next five years of the wild horse population under this alternative approximately 53% of riparian/wetland sites assessed within the HMAs could become severely degraded and/or dewatered (based on the average population growth rate). These impacts would cause a rapid decline in the amount and quality of riparian habitat for many wildlife species. Riparian and wetland sites that are currently rated as "Proper Functioning Condition" would also be at risk of degradation. Over time, drinking water for wildlife would become nonexistent in some areas, or be of very low quality due to the high amount of sediment in the water from horse trampling. Greater sage-grouse habitat would become degraded, especially in riparian and wetland communities. Nesting success would be impacted as sites become devoid of native perennial species and have reduced amounts of plant cover and litter.

4.3.9 Vegetation

The HMAs contains several areas where upland vegetation has been impacted by wildfires, historic livestock grazing, and other disturbances, which has damaged those plant communities. Sites that have low biodiversity have lost a high percentage of their native plant component, are comprised of a higher percentage of shrubs, or have been invaded by annual grasses. Maintaining a balance of grazing animals and controlling the timing and amount of forage that is consumed each year by livestock and wild horses is crucial to maintaining healthy upland plant communities. By removing excess wild horses as described in Alternatives 1, 2, and 3, cumulative impacts are expected to be positive for vegetation resources.

Alternative 4 would result in the increase in wild horse numbers and increased disturbance to native vegetation and soils, which could lead to increased damage to upland vegetation. Plant communities that have been impacted in the past by wildfires and historic livestock grazing would be vulnerable to losing native perennial grasses, due to the high amount of surface disturbance and trampling from excessive wild horses.

As perennial plant cover decreases within the HMAs, annual plant cover from invasive species would increase, as these species are adapted to filling in gaps (areas devoid of vegetation). This change in functional/structural groups would have an impact on the vegetation, forage resources, and soil resources in the HMAs. Soils would become less resistant to trampling impacts and would become more susceptible to wind or water erosion. Many sites that have been previously disturbed would transition from native perennial plant communities to invasive annuals plant (e.g., cheatgrass) communities.

5.0 Consultation and Coordination

5.1 Consultation

The BLM began tribal consultation efforts related to the Carter Reservoir, Buckhorn, Coppersmith HMA Gather in late 2021 with numerous in-person, regularly scheduled consultation meetings that have continue through fiscal year 2024. Based on these discussions, lessons learned from past similar efforts undertaken during the Surprise Complex Gather, and the intention to reduce the number of letters Tribes receive concerning the same undertaking, initial formal consultation letters were not provided in favor of a more comprehensive and final Notice of Availability once a preliminary EA was available. This Notice will be provided to Alturas Rancheria, Cedarville Indian Rancheria, Klamath Tribes, Fort Bidwell Tribe, Modoc Nation, Pit River Tribe, Reno-Sparks Indian Colony, Summit Lake Tribe, and Susanville Indian Rancheria when the EA is posted; to date, the BLM has not received any replies related to its request for consultation or coordination during the efforts noted below, nor any opposition of the gather as proposed.

Specific consultation efforts with specific Tribes have occurred either in-person, via email, and/or via video conference call (Zoom and/or Microsoft Teams) as requested on the following dates:

- Fort Bidwell: 05/26/2022 (in-person meeting); comments made during the meeting indicate that Fort Bidwell supports horse gathers in general but that individual members oppose horse slaughter. Fort Bidwell also expressed interest in adoption of gathered horses following the completion of this gather. Follow-up meetings that included the gather as a discussion topic also occurred on 11/18/2023 and 2/10/2024. No other more gather-specific comments or concerns were received.

- Pit River Tribe: 12/02/2021 (Microsoft Teams call), 03/24/2022 (Microsoft Teams call), and 06/23/2022 (Microsoft Teams call); the Tribe has requested to be informed and involved in all gathers and is supportive of BLM gathers and reducing the number of wild horses and burros currently on public lands in a broad sense. Follow-up meetings that included the gather as a discussion topic also occurred on 6/1/2023, 8/9/2023, 11/1/2023, and 8/7/2024. No other gather-specific comments were received during any of the above meetings.

- Summit Lake: 07/16/2022 (Zoom call); the Tribe had questions about the post-gather process, long-term holding facilities, and disposal options but voiced no specific concerns about this gather or gathers in general. Follow-up meetings that included the gather as a discussion topic also occurred on 5/20/2023, 8/19/2023, 11/18/2023, and 5/18/2024. No other gather-specific comments were received during any of the above meetings.

- Susanville Indian Rancheria (SIR): 11/18/2021 (project updates and summaries provided via email) and 10/11/2022 (in-person meeting); the Tribe had questions about the post-gather process, long-term holding facilities, and disposal options but voiced no specific concerns about this gather or gathers in general. Follow-up meetings that included the gather as a discussion topic also occurred on 4/20/2023, 4/25/2024, and 7/18/2024. No other gather-specific comments were received during any of the above meetings.

- Cedarville Rancheria: 6/19/2024 via in-person meeting; the Tribe had questions about the post-gather process and where horses were held and transported to but no other gather-specific comments have been received since the above meeting was held.

None of the tribes identified any sacred and/or religious sites, traditional resource gathering areas Traditional Cultural Properties (TCPs), sacred sites, cultural, archaeological, or other associated issues or concerns related to proposed trap sites or other associated gather-related activities.

5.2 Coordination and Public Participation

BLM did not consult with USFWS or NMFS because there are no Threatened & Endangered Species being present in the project area. As for public participation, the AGFO publishes Land Use Planning and National Environmental Policy Act (NEPA) documents to the national register known as ePlanning. The register allows public review and comment online on BLM NEPA and planning projects.

6.0 List of Preparers

Table 6-1. The BLM interdisciplinary team members consulted for the Carter Reservoir, Buckhorn, and Coppersmith Herd Management Areas (HMAs) Gather and Population Control Plan Environment Assessment (EA).

Name	Title
Patrick Farris	Project Lead, Wild Horse and Burro Specialist
Megan Banwarth	Planning and Environmental Specialist
Kevin Kunkel	Assistant Field Manager
Jennifer Bonham	Rangeland Management Specialist
Jennifer Mueller	Rangeland Technician
Devin Snyder	Archaeologist
John Morris	Wildlife Biologist
Adam Butler	Outdoor Recreation Specialist

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Appendix A. Map of HMAs: Carter Reservoir, Buckhorn, Coppersmith Herd Management Areas

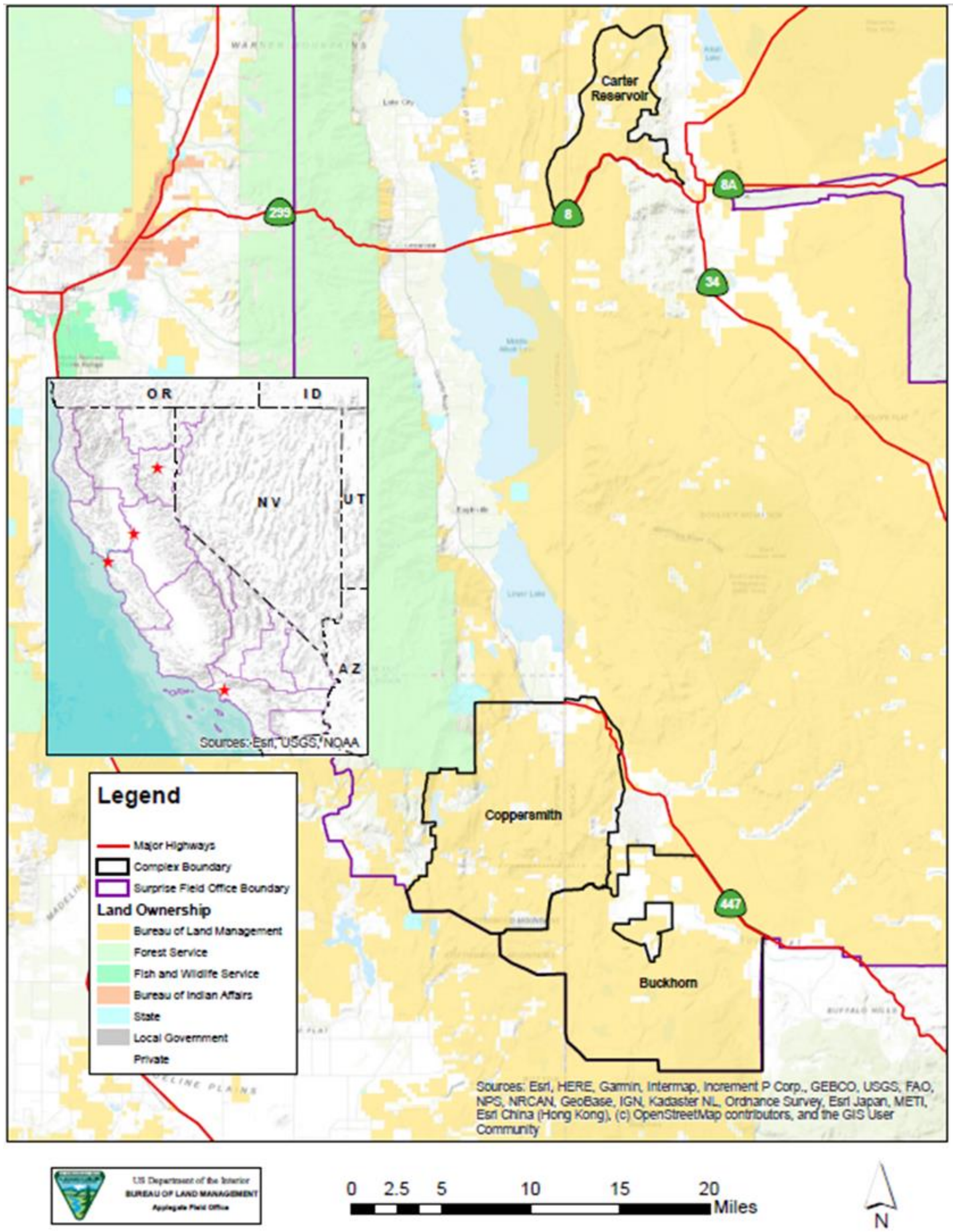

Figure A-1. Map of the HMAs: Carter Reservoir, Buckhorn, and Coppersmith Herd Management Areas (HMA).

Appendix B. Map of Animal Group Sightings On-HMA and Off-HMA from Aerial Survey

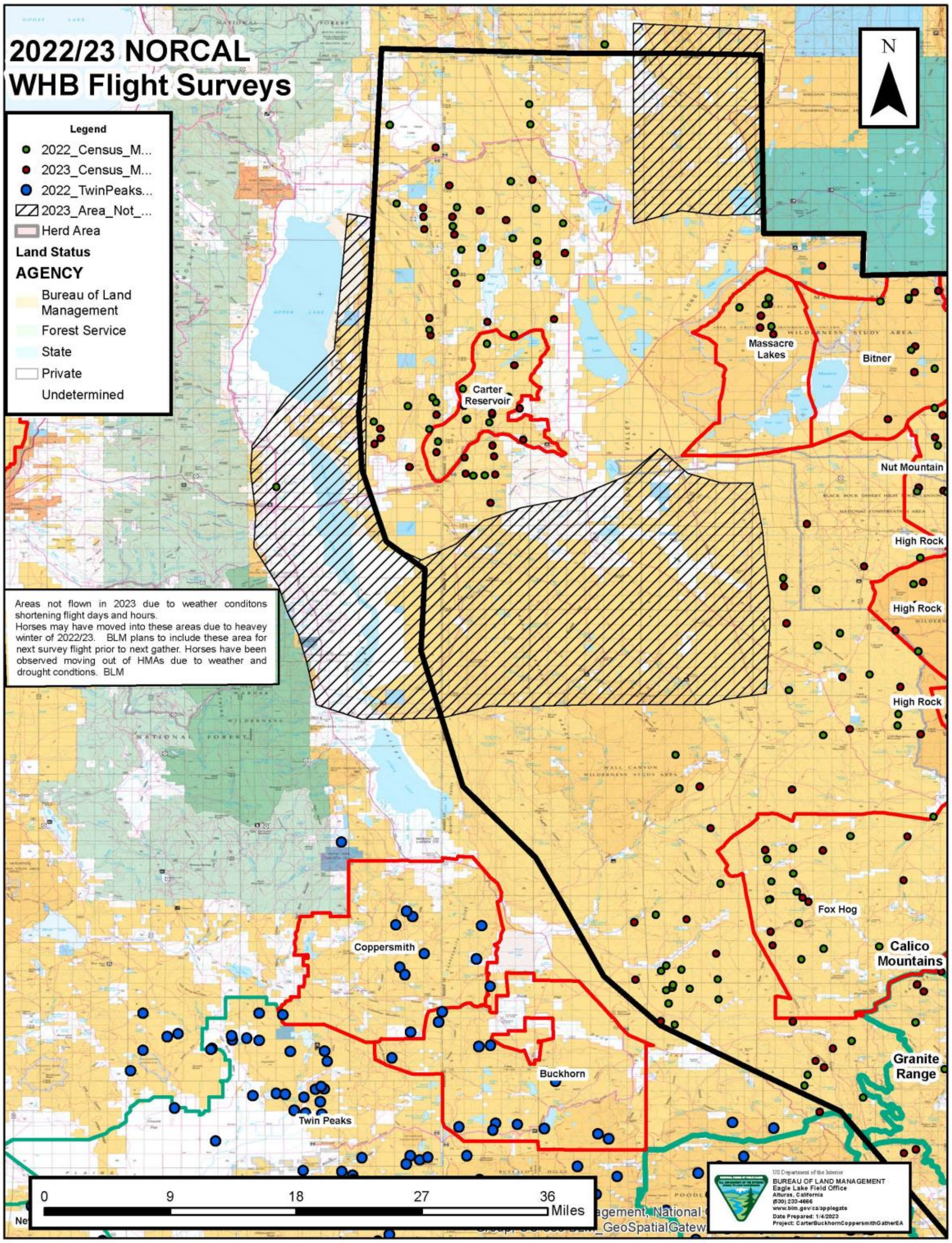

Figure B-1. Map of animal group sightings on-HMA and off-HMA from 2022 & 2023 aerial survey.

Appendix C. 43 CFR § 4700 Applicable Regulations

The Proposed Action is in conformance with the *Wild Free-Roaming Horses and Burros Act of 1971* (as amended), applicable regulations at 43 CFR § 4700, and BLM policies. Included are:

43 CFR § 4710.4 Constraints on Management: Management of wild horses and burros shall be undertaken with the objective of limiting the animals' distribution to herd areas. Management shall be at the minimum feasible level necessary to attain the objectives identified in approved land use plans and herd management area plans.

43 CFR § 4720.1 Removal of excess animals from public lands: Upon examination of current information and a determination by the authorized officer that an excess of wild horses or burros exists, the authorized officer shall remove the excess animals immediately.

43 CFR § 4740.1 Use of motor vehicles or aircraft:

a) Motor vehicles and aircraft may be used by the authorized officer in all phases of the administration of the Act, except that no motor vehicle or aircraft, other than helicopters, shall be used for the purpose of herding or chasing wild horses or burros for capture or destruction. All such use shall be conducted in a humane manner.

b) Before using helicopters or motor vehicles in the management of wild horses or burros, the authorized officer shall conduct a public hearing in the area where such use is to be made.

The Proposed Action is also in conformance with the *Interim Management Policy for Lands under Wilderness Review*, BLM H-8550-1, (July 1995b), Chapter IIIE, Wild Horse and Burro Management, and with other BLM decisions for management of multiple use resources on public lands within this area.

Environmental Assessments, other BLM Documents

The following documents contain information from prior NEPA analyses to which this EA is tiered, and BLM decisions related to land health assessments, livestock grazing, wild horses, and other resources within the HMAs:

1. BLM Environmental Impact Statement, DOI-BLM-CA-N020-0002-RMP-EIS, *Surprise Resource Management Plan and Record of Decision,* 2008.
2. 2021 Surprise Complex Wild Horse and Burro Gather Plan Environmental Assessment (DOI-BLM-CA-N020-2021-0009-EA)
3. 2009 Buckhorn, Coppersmith and Carter Reservoir Wild Horse Herd Management Areas Capture and Remove Plan Environmental Assessment (DOI-BLM-CA-N070-2009-011-EA)
4. BLM Carter Reservoir Herd Management Area Plan, CA-269, 1989.
5. BLM Buckhorn Herd Management Area Plan, CA-262, 1989.
6. BLM Coppersmith Herd Management Area Plan, CA-261, 1989.
7. BLM Land Use Plan, Cowhead-Massacre Management Framework Plan, July 1983.
8. BLM Land Use Plan, Tuledad/Homecamp Management Framework Plan, July 1977.

Appendix D. Maps of Previous and Potential Trap Site Locations

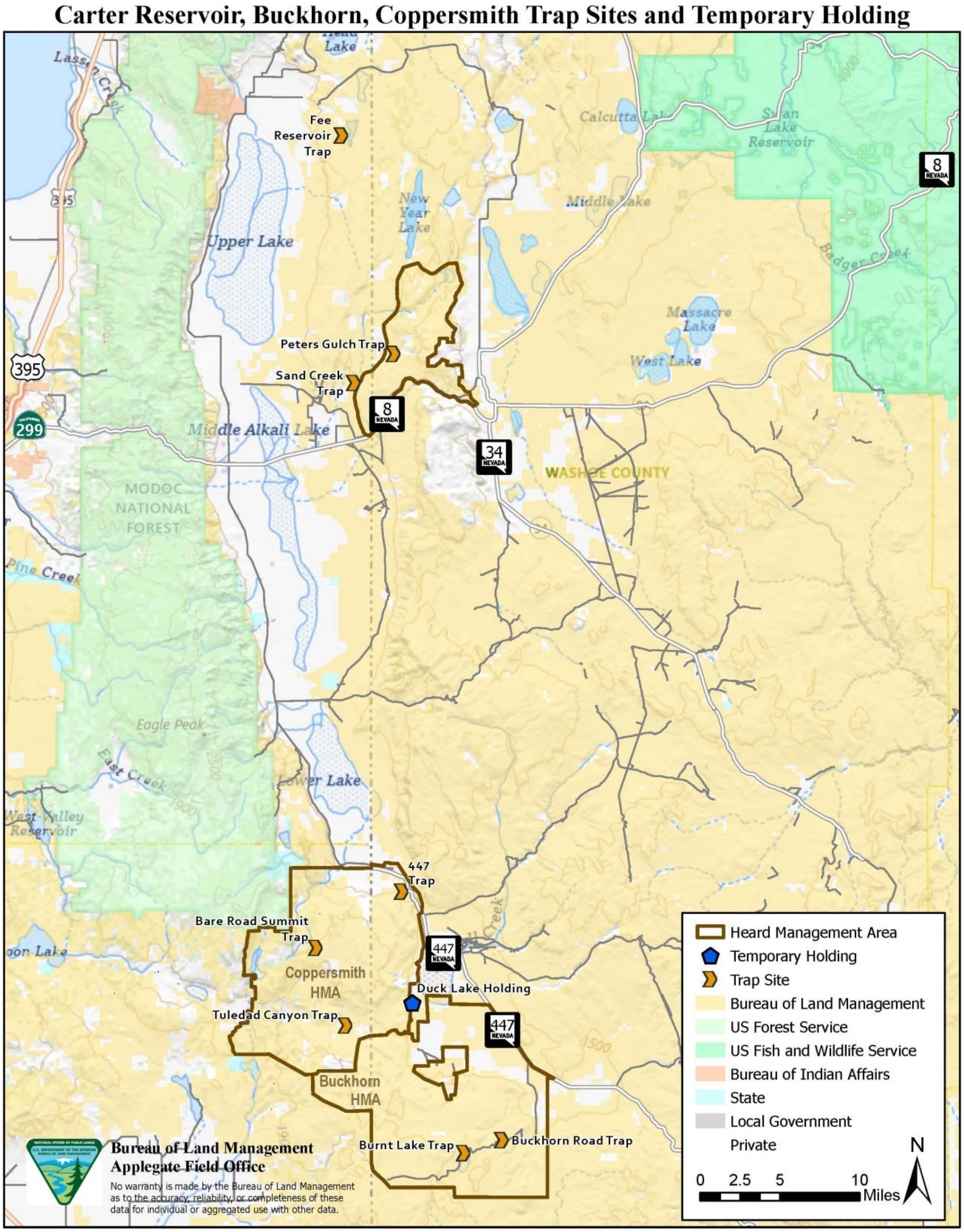

Figure D-1. Map of previous and potential trap site locations in Carter Reservoir, Buckhorn, and Coppersmith HMAs.

Appendix E. Fertility Control Treatment Standard Operating Procedures (SOPs)

SOPs common to all vaccine types:

Animal Identification
Animals intended for treatment must be clearly, individually identifiable to allow for positive identification during subsequent management activities. For captured animals, marking for identification may be accomplished by marking each individual with a freeze mark on the hip or neck and a microchip in the nuchal ligament. In some cases, identification may be accomplished based by cataloguing markings that make animals uniquely identifiable. Such animals may be photographed using a telephoto lens and high-quality digital camera as a record of treated individuals.

Safety
Safety for both humans and animals is the primary consideration in all elements of fertility control vaccine use. Administration of any vaccine must follow all safety guidance and label guidelines on applicable EPA labeling.

Injection Site
For hand-injection, delivery of the vaccine should be by intramuscular injection, while the animal is standing still, into the left or right side, above the imaginary line that connects the point of the hip (hook bone) and the point of the buttocks (pin bone): this is the hip / upper gluteal area. For dart-based injection, delivery of the vaccine should be by intramuscular injection, while the animal is standing still, into the left or right thigh areas (lower gluteal / biceps femoralis).

Monitoring and Tracking of Treatments
1. Estimation of population size and growth rates (in most cases, using aerial surveys) should be conducted periodically after treatments.
2. Population growth rates of some herds selected for intensive monitoring may be estimated every year post-treatment using aerial surveys. If, during routine HMA field monitoring (on-the-ground), data describing adult to foal ratios can be collected, these data should also be shared with HQ-261.
3. Field applicators should record all pertinent data relating to identification of treated animals (including photographs if animals are not freeze marked) and date of treatment, lot number(s) of the vaccine, quantity of vaccine issued, the quantity used, the date of vaccination, disposition of any unused vaccine, the date disposed, the number of treated mares by HMA, field office, and State along with the microchip numbers and freeze mark(s) applied by HMA and date. A summary narrative and data sheets would be forwarded to HQ-261 annually (Reno, Nevada). A copy of the form and data sheets and any photos taken should be maintained at the field office.
4. HQ-261 would maintain records sent from field offices, on the quantity of PZP issued, the quantity used, disposition of any unused PZP, the number of treated mares by HMA, field office, and State along with the freeze mark(s) applied by HMA and date.

SOPs for one-year liquid PZP vaccine (ZonaStat-H)
ZonaStat-H vaccine (Science and Conservation Center, Billings, MT) would be administered through hand-injection or darting by trained BLM personnel or collaborating partners only. At present, the only PZP vaccine for dart-based delivery in BLM-managed wild horses or burros is ZonaStat-H. For any darting operation, the designated personnel must have successfully completed a nationally recognized wildlife darting course and who have documented and successful experience darting wildlife under field conditions.

Until the day of its use, ZonaStat-H must be kept frozen, except that an emulsified dose that is not used may be refrigerated overnight, then used the following day.

Animals that have never been treated with a PZP vaccine would receive 0.5 cc go of PZP vaccine emulsified with 0.5 cc of Freund's Modified Adjuvant (FMA). Animals identified for re-treatment receive 0.5 cc of the PZP vaccine emulsified with 0.5 cc of Freund's Incomplete Adjuvant (FIA). Consistent with EPA guidelines, animals may be held in captivity for at least 2 weeks between primer and booster doses of PZP ZonaStat-H vaccine.

Hand-injection of liquid PZP vaccine would be by intramuscular injection into the gluteal muscles while the animal is restrained in a working chute. The vaccine would be injected into the left hind quarters of the animal, above the imaginary line that connects the point of the hip (hook bone) and the point of the buttocks (pin bone).

For hand-injection, delivery of the vaccine would be by intramuscular injection into the left or right buttocks and thigh muscles (gluteals, biceps femoris) while the animal is standing still.

Application of ZonaStat-H via Darting

Only designated darters would prepare the emulsion. Vaccine-adjuvant emulsion would be loaded into darts at the darting site and delivered by means of a projector gun.

No attempt to dart should be taken when other persons are within a 100-m radius of the target animal. The Dan Inject gun should not be used at ranges in excess of 30 m while the Pneu-Dart gun should not be used over 50 m.

No attempts would be taken in high wind (greater than 15 mph) or when the animal is standing at an angle where the dart could miss the target area and hit the flank or rib cage. The ideal is when the dart would strike the skin of the animal at a 90° angle.

If a loaded dart is not used within two hours of the time of loading, the contents would be transferred to a new dart before attempting another animal. If the dart is not used before the end of the day, it would be stored under refrigeration and the contents transferred to another dart the next day, for a maximum of one transfer (discard contents if not used on the second day). Refrigerated darts would not be used in the field.

A darting team should include two people. The second person is responsible for locating fired darts. The second person should also be responsible for identifying the animal and keeping onlookers at a safe distance.

To the extent possible, all darting would be carried out in a discrete manner. However, if darting is to be done within view of non-participants or members of the public, an explanation of the nature of the project would be carried out either immediately before or after the darting.

Attempts would be made to recover all darts. To the extent possible, all darts which are discharged and drop from the target animal at the darting site would be recovered before another darting occurs. In exceptional situations, the site of a lost dart may be noted and marked, and recovery efforts made at a later time. All discharged darts would be examined after recovery in order to determine if the charge fired and the plunger fully expelled the vaccine. Personnel conducting darting operations should be equipped with a two-way radio or cell phone to provide a communications link with a project veterinarian for advice and/or assistance. In the event of a veterinary emergency, darting personnel would immediately contact the project veterinarian, providing all available information concerning the nature and location of the incident.

In the event that a dart strikes a bone or imbeds in soft tissue and does not dislodge, the darter would follow the affected animal until the dart falls out or the animal can no longer be found. The darter would be responsible for daily observation of the animal until the situation is resolved.

SOPs for application of PZP-22 pelleted vaccine:
PZP-22 pelleted vaccine treatment would be administered only by trained BLM personnel or designated partners.

A treatment of PZP-22 is comprised of two separate injections: (1) a liquid dose of PZP vaccine (equivalent to one dose of ZonaStat-H) is administered using an 18-gauge needle primarily by hand injection; (2) the pellets are preloaded into a 14-gauge needle. For animals constrained in a working chute, these are delivered using a modified syringe and jabstick to inject the pellets into the gluteal muscles of the animals being returned to the range. The pellets are intended to release PZP over time.
Until the day of its use, the liquid portion of PZP-22 must be kept frozen.

Delivery of PZP-22 treatment would primarily be by intramuscular injection into the gluteal muscles while the animal is restrained in a working chute. The primer would consist of 0.5 cc of liquid PZP emulsified with 0.5 cc of adjuvant. Animals that have never been treated with a PZP vaccine would receive 0.5 cc of PZP vaccine emulsified with 0.5 cc of Freund's Modified Adjuvant (FMA). Animals identified for re-treatment receive 0.5 cc of the PZP vaccine emulsified with 0.5 cc of Freund's Incomplete Adjuvant (FIA). The syringe with PZP vaccine pellets would be loaded into the jabstick for the second injection. With each injection, the liquid or pellets would be injected into the left hind quarters of the animal, above the imaginary line that connects the point of the hip (hook bone) and the point of the buttocks (pin bone).

The PZP-22 treatment may be administered remotely using a darting protocol and delivery system, consistent with published studies that have found that method effective (Rutberg et al., 2017; Carey et al., 2019).

SOPs for GonaCon-Equine Vaccine Treatments
GonaCon-Equine vaccine (USDA Pocatello Storage Depot, Pocatello, ID; Spay First!, Inc., Oklahoma City, OK) is distributed as preloaded doses (2 mL) in labeled syringes. Upon receipt, the vaccine should be kept refrigerated (4° C) until use. <u>Do not freeze GonaCon-Equine</u>. The vaccine has a 6-month shelf-life from the time of production and the expiration date would be noted on each syringe that is provided. For initial and booster treatments, mares would ideally receive 2.0 ml of GonaCon-Equine.

Administering GonaCon Vaccine by Hand-Injection
Experience has demonstrated that only 1.8 ml of vaccine can typically be loaded into 2 cc darts, and this dose has proven successful. Calculations below reflect a 1.8 ml dose.

For hand-injection, delivery of the vaccine should be by intramuscular injection, while the animal is standing still, into the left or right side, above the imaginary line that connects the point of the hip (hook bone) and the point of the buttocks (pin bone): this is the hip / upper gluteal area.

A booster vaccine may be administered after the first injection to improve efficacy of the product over subsequent years. Consistent with EPA guidelines, animals may be held in captivity for at least 30 days between primer and booster doses of GonaCon-Equine vaccine.

Application of GonaCon-Equine via Darting

General practice guidelines for darting operations, as noted above for dart-delivery of ZonaStat-H, should be followed for dart-delivery of GonaCon-Equine.

Wearing latex gloves, the applicator numbers the darts, and loads the numbered darts with vaccine by attaching a loading needle (7.62 cm; provided by dart manufacturer) to the syringe containing vaccine and placing the needle into the cannula of the dart to the fullest depth possible. Slowly depress the syringe plunger and begin filling the dart. Periodically, tap the dart on a hard surface to dislodge air bubbles trapped within the vaccine. Due to the viscous nature of the fluid, air entrapment typically results in a maximum of approximately 1.8 ml of vaccine being loaded in the dart. The dart is filled to max once a small amount of the vaccine can be seen at the tri-ports.

An alternate method for loading 2cc darts that overcomes the problem of air entrapment requires the use of a centrifuge. For this procedure, load darts by syringe to approximately 70% (1.4 ml), place darts tail down in centrifuge tubes (balancing with opposing tubes, filling all tubes, etc.), and run at 500 – 1000 revolutions per minute for one minute duration. Remove darts from centrifuge and continue filling with matching syringe contents, repeating centrifugation as necessary, until the full 2ml is loaded to darts.

Dart injections are not to be loaded and refrigerated the night before application. When exposed to moisture and condensation, the edges of gel barbs soften, begin to dissolve, and would not hold the dart in the muscle tissue long enough for full injection of the vaccine. The dart needs to remain in the muscle tissue for a minimum of 1 minute to achieve dependable full injection. Sharp gel barbs are critical for successful injection of a full dose.

Darts should be weighed to the nearest hundredth gram by electronic scale when empty, when loaded with vaccine, and after discharge, to ensure that 90% (1.62 ml) of the vaccine has been injected. GonaCon weighs 0.95 grams/mL, so animals should receive 1.54 grams of vaccine to be considered treated. Animals receiving <50% should be darted with another full dose; those receiving >50% but <90% should receive a half dose (1 ml). All darts should be weighed to verify a combination of ≥1.62 ml has been administered. Therefore, every effort should be made to recover darts after they have fallen from animals.

Although infrequent, dart injections can result in partial injections of the vaccine, and shots are missed. As a precaution, it is recommended that extra doses of the vaccine be ordered to accommodate failed delivery (which may be as high as ~15 %). To determine the amount of vaccine delivered, the dart must be weighed before loading, and before and after delivery in the field. The scale should be sensitive to 0.01 grams or less, and accurate to 0.05 g or less.

For best results, darts with a gel barb should be used. (i.e., 2 cc Pneu-Dart brand darts configured with Slow-inject technology, 3.81 cm long 14 ga. tri-port needles, and gel collars positioned 1.27 cm ahead of the ferrule). One can expect updates in optimal dart configuration, pending results of research and field applications.

Darts (configured specifically as described above) can be loaded in the field and stored in a cooler prior to application. Darts loaded, but not used can be maintained in dry conditions at about 4° C and used the next day, but do not store in any refrigerator or container likely to cause condensation, which can compromise the gel barbs.

SOPs for Insertion of Y-shaped Silicone Intrauterine Devices for Feral Horses

Background
Mares must be open. A veterinarian must determine pregnancy status via palpation or ultrasound. Ultrasound should be used as necessary to confirm open status of mares down to at least 14 days for those that have recently been with stallions. For mares segregated from stallions, this determination may be made at an earlier time when mares are identified as candidates for treatment, or immediately prior to IUD insertion. Pregnant mares should not receive an IUD.

Preparation
IUDs must be clean and sterile. Sterilize IUDs with a low-temperature sterilization system, such as Sterrad.

The Introducer is two PVC pipes. The exterior pipe is a 29” length of ½” diameter pipe, sanded smooth at one end, then heat-treated to smooth its curvature further (Fig. 1). The IUD would be placed into this smoothed end of the exterior pipe. The interior pipe is a 29 ½” long, ¼” riser tube (of the kind used to connect water lines to sinks), with one end slightly flared out to fit more snugly inside the exterior pipe (Fig. 1), and a plastic stopper attached to the other end (Figure E-1).

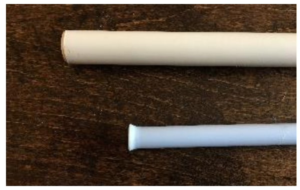

Figure E-1. Interior and exterior pipes (unassembled), showing the ends that go into the mare.

Figure E-2. Interior pipe shown within exterior pipe. After the introducer is 4” beyond the os, the stopper is pushed forward (outside the mare), causing the IUD to be pushed out from the exterior pipe.

Introducers should be sterilized in Benz-all cold sterilant, or similar. Do not use iodine-based sterilant solution. A suitable container for sterilant can be a large diameter (i.e., 2”) PVC pipe with one end sealed and one end removable.

Prepare the IUD: Lubricate with sterile veterinary lube and insert into the introducer. The central stem of the IUD goes in first (Figure E-3).

Figure E-3. Insert the stem end of the IUD into the exterior pipe.

Fold the two ‘legs’ of the IUD, and push the IUD further into the introducer, until just the bulbous ends are showing (Figure E-4).

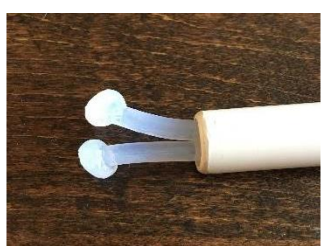

Figure E-4. Insert the IUD until just the tips of the ‘legs’ are showing.

Restraint and Medication

The mare should be restrained in a padded squeeze chute to provide access to the rear end of the animal, but with a solid lower back door, or thick wood panel, for veterinarian safety.

Some practitioners may choose to provide sedation. If so, when the mare's head starts to droop, it may be advisable to tie the tail up to prevent risk of the animal sitting down on the veterinarian's arm (i.e., double half hitch, then tie tail to the bar above the animal).
Some practitioners may choose to provide a dose of long-acting progesterone to aid in IUD retention. Example dosage: 5mL of BioRelease LA Progesterone 300 mg/mL (BET labs, Lexington KY), *or* long-acting Altrenogest). No other intrauterine treatments of any kind should be administered at the time of IUD insertion.

Insertion Procedure

- ➔ Prep/clean the perineal area.
- ➔ Lubricate the veterinarian's sleeved arm and the Introducer + IUD.
- ➔ Carry the introducer (IUD-end-first) into the vagina.
- ➔ Dilate the cervix and gently move the tip of the introducer past the cervix.
- ➔ Advance the end of the 1/2" PVC pipe about 4 inches past the internal os of the cervix.
- ➔ Hold the exterior pipe in place, but push the stopper of the interior pipe forward, causing the IUD to be pushed out of the exterior pipe, into the uterus.
- ➔ Placing a finger into the cervical lumen just as the introducer tube is removed from the external os allows the veterinarian to know that the IUD is left in the uterus, and not dragged back into or past the cervix.
- ➔ Remove the introducer from the animal, untie the tail.

Mares that have received an IUD should be observed closely for signs of discharge or discomfort for 24 hours following insertion after which they may be released back to the range.

Y-Shaped Silicone IUD for Feral Horses

The *Y-Shaped Silicone IUD for Feral Horses* is an intrauterine device (IUD) comprised solely of medical-grade, inert, silicone that is suitable for use in female feral horses (free-roaming or "wild" *Equus caballus*). Intended users include government agencies with feral horses in their management purview, Native American tribes that have management authority over feral horses, and authorized feral horse care or rescue sanctuaries that manage feral horses in a free ranging environment.

The *Y-Shaped Silicone IUD for Feral Horses* can mitigate or reduce feral horse population growth rates because these IUDs can provide potentially reversible fertility control for female feral horses. This IUD prevents pregnancy by its physical presence in the mare's uterus as long as the IUD stays in place. In trials, approximately 75% of mares living and breeding with fertile stallions retained the *Y-Shaped Silicone IUD for Feral Horses* over two breeding seasons. None of the mares that kept their IUDs became pregnant during an experimental trial. After IUD removal, the majority of mares returned to fertility.

Directions for Use:

The *Y-Shaped Silicone IUD for Feral Horses* is to be placed in the uterus of feral horse mares by a veterinarian. The *Y-Shaped Silicone IUD for Feral Horses* is intended for use in feral mares that are at least approximately 1 year old, where age is determined based on available evidence, such as tooth eruption pattern.

IUDs must be sterilized before use. The IUD is inserted into the uterus using a thin, tubular applicator, similar to a shielded culture tube commonly used in equine reproductive veterinary medicine, in a manner similar to methods used for uterine culture of domestic mares. Feral mares with IUDs should be individually marked and identified (i.e., with an RFID microchip, or via visible freeze-brand on the hip or neck).

Caution:

These IUDs are only to be used in mares that are confirmed to be not pregnant. Checking pregnancy status can be accomplished by methods such as a transrectal palpation and/or ultrasound performed by a veterinarian. If a *Y-Shaped Silicone IUD for Feral Horses* is inserted in the uterus of a pregnant mare, it may cause the pregnancy to terminate, and the IUD to be expelled.

Manufactured for:
U.S. Bureau of Land Management (97949)
1340 Financial Blvd., Reno, NV 89052
EPA Est.: 97628-MI-1

Figure E-5. Label for Y-shaped silicone IUD for feral horses.

Appendix F. Map of Grazing Allotments within the HMAs

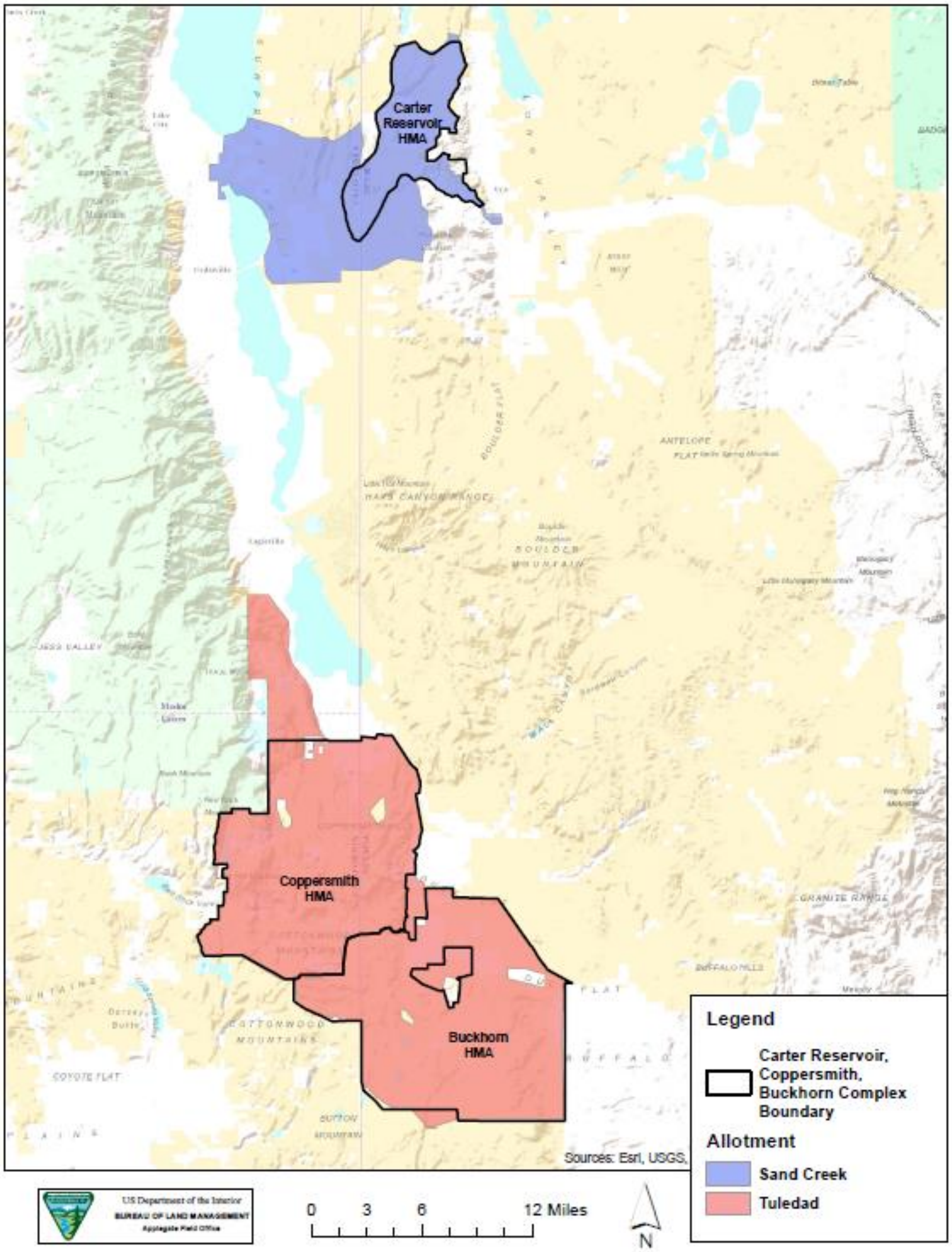

Figure F-1. The grazing allotments within the Carter Reservoir, Buckhorn, and Coppersmith Herd Management Areas (HMAs).

Appendix G. Grazing Management Actions between 1982 and 2022

Table G-1. Grazing management actions between 1982 and 2022 of the allotments within the Carter Reservoir, Buckhorn, and Coppersmith HMAs.

Livestock Grazing Allotment Name	Reduction in Livestock AUMs/Closures	Increase in Livestock AUMs	Change in Season of Use/ Livestock Class	Change in Grazing Strategy	Riparian Area Restrictions/ Other Restrictions
Sand Creek	None since 1984. Temporary reduction of 221 AUMs in 2001 and 2002 due to Lake Fire.	None	Current: Cattle, 4/1 – 9/30	Current: Fenced pastures, rest rotation with deferred use. 2 seeding pastures. Past: Common grazing unit including Sand Creek, Bull Creek, and Long Valley with turnout and use areas.	7 spring and riparian area fenced exclosures. Riparian restrictions on public portions of Sand Creek.
Tuledad	Reduction of 1045 AUMs since 1980. Temporary reductions of AUMs due to fires between 1994 and 2002. 7850 acres closed to grazing due to Rush fire in 2013 – 2015. No reduction in AUMs. 23 % Temporary AUM reduction due to W5 – Cold Springs Fire from 2021-2022. Closure areas: Snake Lake, Coppersmith Hills, Wire Lakes.	None	Current: Sheep and cattle, 4/1 – 9/30 (flexible turnout date based on range conditions)	Current: Designated hot season use areas, seeding pastures, and alternate turnout areas. Past: Season long continuous grazing.	20 spring and riparian areas fenced exclosures. Allowable use limit restrictions on public riparian areas.

Appendix H. Livestock Actual Use Table 2010-2022

Table H-1. The livestock actual use from 2010 through 2022 of the Sand Creek and Tuledad Allotments.

CARTER RESERVOIR, BUCKHORN, and COPPERSMITH COMPLEX GRAZING ALLOTMENTS				Varies within Dates		ANNUAL ACTUAL USE BY ALLOTMENT												
Allotment Number	Allotment Name	Livestock Kind	Permitted AUMs	Period Begin Date	Period End Date	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
01012	SAND CREEK	CATTLE	3,647	4/1	9/30	2,496	3,206	2,870	2,961	2,075	2,421	3,438	2,695	2,541	3,272	2,766	2,033	3,032
00802	TULEDAD	CATTLE & SHEEP	9,505	3/26	10/15	5,674	7,124	7,150	7,626	5,577	7,640	6,990	6,683	6,436	6,559	6,845	5,293	4,216
Total Livestock Use			13,152			8,170	10,330	10,020	10,587	7,652	10,061	10,428	9,378	8,977	9,831	9,611	7,326	7,248

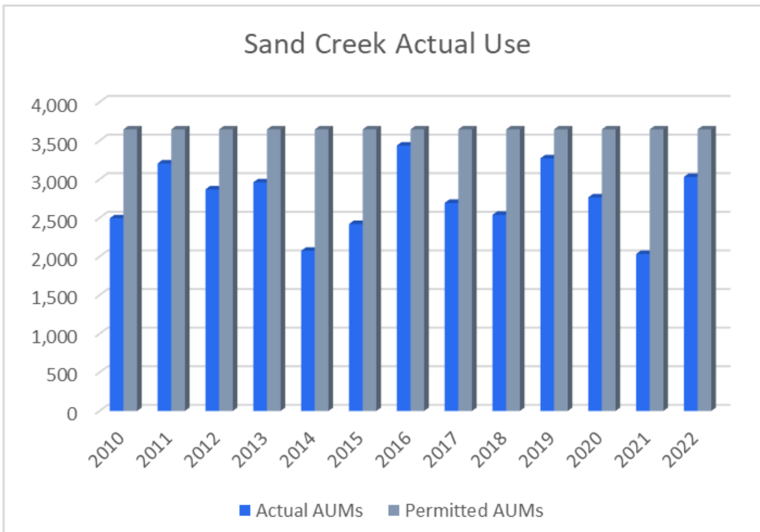

Figure H-1. The actual and permitted use for the Sand Creek Allotment from 2010 through 2022.

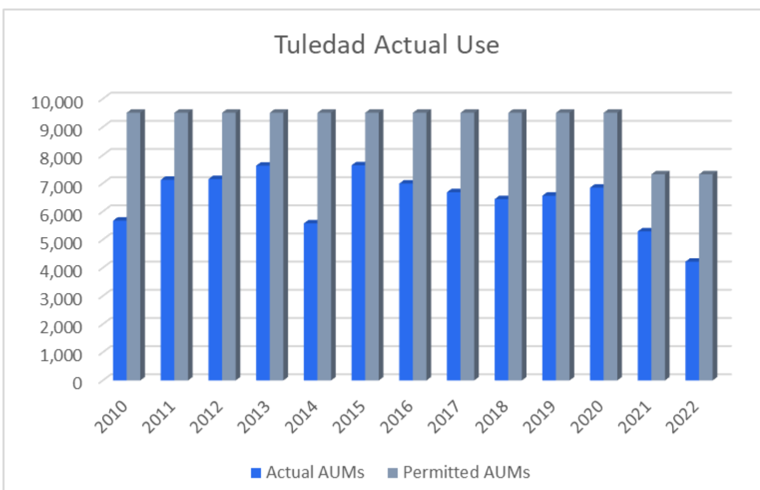

Figure H-2. The actual and permitted use for the Tuledad Allotment from 2010 through 2022.

Appendix I. 2022 HMAs Riparian Report

Introduction

In semi-arid landscapes such as the sagebrush steppe, often the first areas to show signs of ecological distress are riparian areas. Riparian areas are the parts of the landscape that are immediately adjacent to water, are influenced by the presence of the water, and act as a transition between aquatic and upland areas. They are complex, dynamic ecosystems defined by specific geomorphological, hydrological, and vegetative attributes (e.g., hydric soils, wetland obligate vegetation species). Riparian areas serve as critical habitat for many wildlife species and the associated surface waters are important drinking water sources for most species of the sagebrush steppe. Properly functioning riparian systems have a high degree of resistance and resilience to disturbances, including grazing. They are able to dissipate energies associated with overland flow, develop root masses that protect soil surfaces from erosion, improve floodwater retention and ground-water recharge, resist water percolation, maintain geomorphic and soil characteristics, and direct physical alteration from human and animal activities (Gonzales & Smith, 2020).

Methods

A water source survey was completed for the HMAs using the PFC database and Google Earth Pro® imagery. Imagery sources incorporated Landsat, Copernicus, U.S.D.A. Farm Service Agency, U.S. Geological Survey, and other sensors. A careful study was made of imagery and all water sources in each HMA were identified and categorized. Riparian functional assessments are only conducted on systems that are relatively natural and generally have the capability to support riparian vegetation. Stock tanks, ephemeral playas, dugouts, pit reservoirs, and wells are not assessed using the Proper Functioning Condition assessment. The Proper Functioning Condition (PFC) assessment has been around approximately 30 years and is used for both lentic and lotic systems. The abbreviation PFC describes both the assessment process and an on-the-ground condition of a system.

After all water sources were identified, systems without PFC potential were eliminated from further consideration. Each HMA was considered independent from other HMAs. Springs, seeps, and streams for each HMA were evaluated for PFC potential. Springs, seeps, and streams were chosen for assessment based on land ownership (federally managed water sources were preferred), accessibility, use (a range of uses was selected), and spatial balance across each HMA. Since each HMA is unique, the proportion of selected water sources was different for each HMA.

In the PFC assessment process, an interdisciplinary team travels to each chosen location to perform an assessment. Team members work together to complete the assessment. Sites are assessed on several ecological attributes under the subcategories of hydrology, geomorphology and soils, and vegetation. The team works together to identify any ecological attributes that are not functioning as expected. After ecological attributes that are not functioning have been identified, the team assigns the area one of the following ratings: 1) Proper Functioning Condition (PFC), Functional - At Risk (FAR), or Nonfunctional (NF). For PFC and FAR, additional qualifiers of 1) high, 2) mid, or 3) low are added using a thermometer diagram (Figure I-1). Additionally, the team may elect to further quantify Functional - At Risk trend. How the team decides on the ratings is based on the amount, severity, and weight of indicators that are not functioning. Most of the lentic areas have a natural potential and were assessed as such. Some, however, have been modified historically and have an altered potential (e.g., spring with dugout reservoir) but are still able to be assessed using PFC.

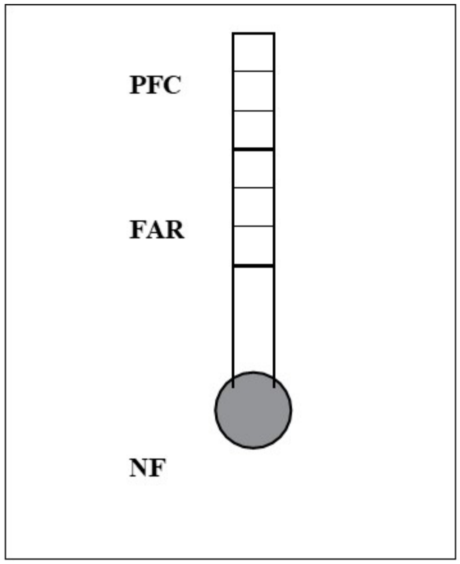

Figure I-1. The scale of ratings for sites.

Results

In the HMAs, 34 riparian areas were selected to be assessed (map of assessment locations follows report conclusion).

Table I-1. Information regarding the water sources within the HMAs.

HMA	Total Number of Water Sources	Number of Assessable Water Sources*	Water Sources Assessed	HMA Acres
Carter Reservoir	23	9	6	23,423
Buckhorn	89	25	7	85,938
Coppersmith	86	46	21	86,820
HMAs	198	80	*34*	*196,181*

*More than half of potential assessable water sources have gone dry, no longer produce surface water and do not support riparian vegetation or riparian function, which is a requirement of the PFC assessment.

Some of the same riparian areas were assessed as part of data gathering efforts and informing the 2009 Buckhorn, Coppersmith, and Carter Reservoir Wild Horse Herd Management Areas Capture and Remove Plan. In general, there are fewer riparian areas with a PFC rating and more with FAR and NF ratings as landscapes continue to be degraded by excessive wild horses. Additionally, natural desiccation has been exacerbated by continued, excessive, overuse by wild horses. Out of the 34 riparian areas in the HMAs assessed; 35% (n = 12) were rated as Proper Functioning Condition (PFC), 53% (n = 18) were rated as Functional - At Risk (FAR), and 12% (n = 4) were rated as Nonfunctional. Most of these riparian areas are small (<5 acres) but are critical areas in arid landscapes.

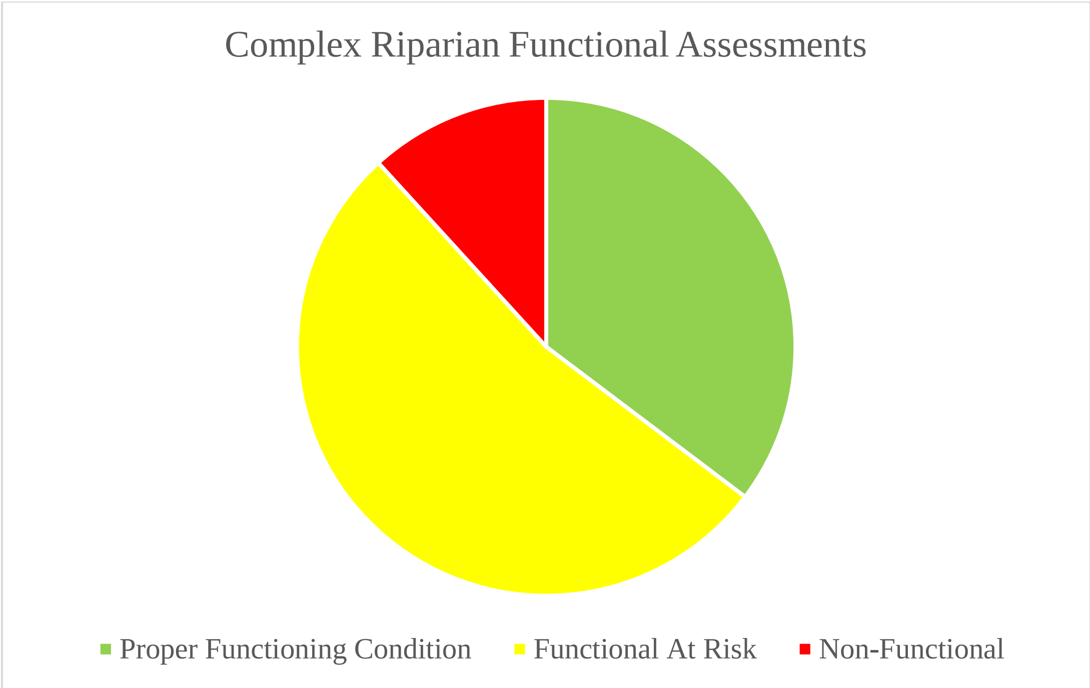

Figure I-2. The riparian functional assessments for the HMAs.

Figure I-3. Example of a large seep complex site that was rated as NF due to loss of hydric soils, erosion, hummocking, lack of riparian vegetation, and extensive bare ground.

Buckhorn HMA

Table I-2. Springs and their ratings with the Buckhorn HMA.

Spring	Date Completed	Rating	Apparent Trend	Protected
Burnt Lake Spring Area	22 Oct 2020	NF	Downward	No
Chalk Hill Spring	20 July 2021	FAR	Not Apparent	No
Duck Flat Wash	10 Aug 21	FAR	Not Apparent	No
Rowland Spring (Outside Exclosure)	16 July 2018	FAR	Not Apparent	No
Rowland Spring Exclosure	16 July 2018	PFC	Upward	Yes
Whorland Reservoir # 2	10 Aug 2021	NF	Not Apparent	Yes
Willow Lake Springs	22 Oct 2020	NF	Downward	No

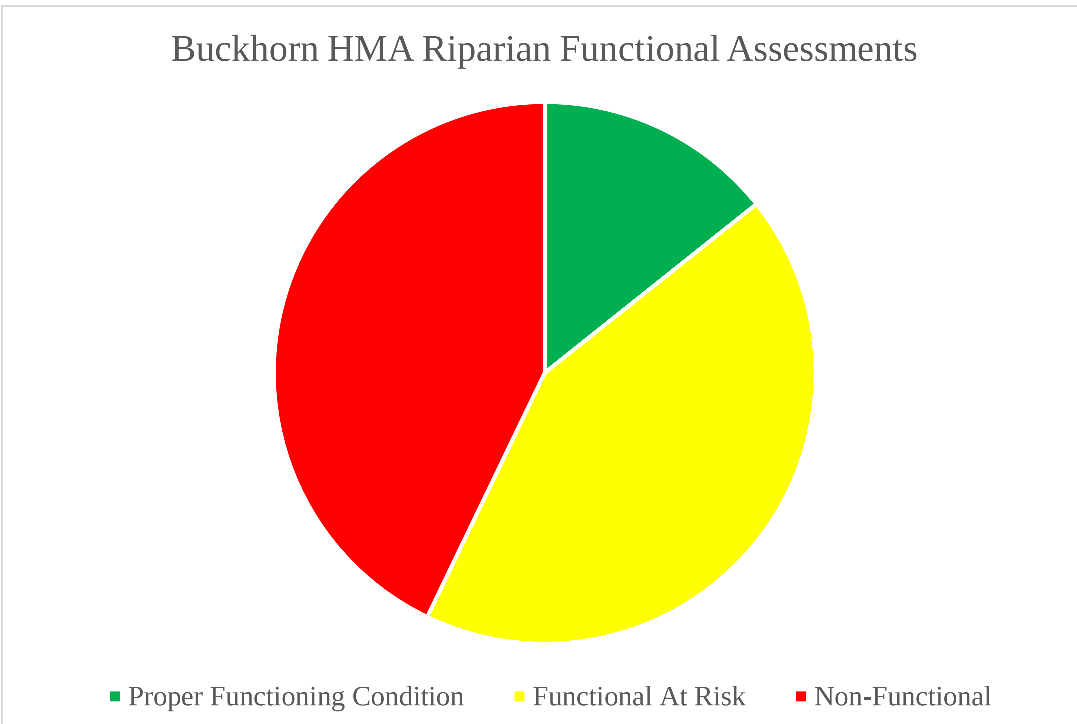

Figure I-4. The riparian functional assessments for the Buckhorn HMA.

Buckhorn HMA has a variety of water sources; pit reservoirs, wells, ephemeral lakes, perennial creeks, and spring/seep systems. These water sources occur on both private and public lands. In general, water supply is not a limiting factor for wild horses in the HMA, except during drought years when ephemeral lakes, reservoirs, and small springs would go dry. Assessed springs in Buckhorn HMA are in varying condition based on development, riparian protection exclosures, and domestic livestock and wild horse use.

Proper Functioning Condition

Figure I-5. Rowland Spring Exclosure is still recovering from severe historical degradation. The riparian area has revegetated and is expanding. Rowland Spring Exclosure was rated as Proper Functioning Condition.

Rowland Spring Exclosure is the only spring in the Buckhorn HMA that was rated at PFC. Rowland Spring has an exclosure that prevents grazing by large ungulates and has allowed recovery of this historically severely degraded system. Although there is still evidence from historical disturbances, the system is recovering and continuing to expand since the exclosure was constructed in 2014. Recruitment and reestablishment of obligate (OBL) and facultative wetland (FACW) vegetation is occurring to the point where senescent material starting to appear. Light disturbance in this situation would be beneficial, but this spring would quickly return to a Functional-at-Risk state (as documented with the assessment completed outside the exclosure) with any recurring, extensive grazing.

Functional - At Risk

In comparison to the spring exclosure, an assessment of Rowland Spring (Outside Exclosure) was completed and rated FAR-Mid. Where livestock and wild horse grazing is chronic and concentrated on the riparian area, the system becomes degraded and channelized due to increased hoof action and trampling disturbances. Stabilizing, deep-rooted obligate species are absent, and the overall system is shrinking.

Chalk Hill Spring is a small lentic system that has historically received a significant amount of disturbance including homesteading and overgrazing by sheep, cattle, and wild horses. Recent drought conditions have restricted the capabilities of this system in terms of water availability and size. When assessed, there was no surface water; however, plant communities still support wetland OBL and FACW species, so water is not far from the surface. The system is receding both in width and length and lacks favorable microsite conditions necessary to maintain water temperature and provide the shade required to regulate temperature for germination. Loss of soil, encroachment of upland species, and lack of water contributed to this FAR rating.

Figure I-6. Duck Flat Wash has is an altered spring with developments and infrastructure. Water is being diverted from the system degrading the hydric functionality of the spring. Continued used from livestock and wild horses exacerbates these conditions. Duck Flat Wash Spring was rated as Functional-At-Risk.

Duck Flat Wash Spring, historically a larger system, has been significantly impaired by physical alteration, anthropogenic infrastructure, and recent drought conditions. Natural flow patterns have been altered by excessive hoof action, dams, roads, diversion pipes, and flow regulations. The spring system is shrinking due to overuse, dewatering due to alterations, soil loss, and channelization. The edges are drying, and riparian vegetation is being replaced by upland species.

Nonfunctional

Many springs within the Buckhorn HMA have been naturally desiccated as climate warms and drought conditions persist. Groundwater is not recharging as it was historically, so many of the springs are now drying. However, natural desiccation is intensified in most cases by chronic, excessive overuse. Lowering of the water table, dewatering of systems, loss of vegetation, missing functional and structural groups, loss of hydric soils, large, connected patches of bare ground, severe pugging, and excessive erosion are all common to these nonfunctional systems.

Figure I-7. Burnt Lake Springs sits within an ephemeral lakebed and receives periods of inundation. Decreased ground water recharge, coupled with excessive livestock and wild horse use has led to extreme erosion of hydric soils, loss of vegetation, increased bare soil, pugging, and drying of many seeps. Burnt Lake Springs was rated as Nonfunctional.

Figure I-8. The spring head of Whorland #2, shown in the picture, is located within a riparian exclosure, however the fence is not functional. Excessive trampling and overgrazing, coupled with prolonged drought conditions, has led to extreme erosion, hummocking, gullies, loss of hydric vegetation and soils, and disruption of ecosystem goods and services. Whorland #2 was rated as Nonfunctional.

Figure I-9. Willow Lake Springs has been excessively overused and has lost many critical ecological functions. Excessive erosion of hydric soils, lack of stabilizing vegetation, cuts, hoof action, and abundant interconnected bare soil patches have degraded this system. Willow Lake Springs was rated as Nonfunctional.

Coppersmith HMA

Table I-3. Springs and their ratings within the Coppersmith HMA.

Spring	Date Completed	Rating	Apparent Trend	Protected
Ant Spring (Outside Exclosure)	24 Sept 2019	PFC	Upward	No
Ant Spring Exclosure	24 Sept 2019	PFC	Upward	Yes
Bare Creek	3 Aug 2021	FAR	Downward	Yes
Bird Bath Spring	17 Sept 2019	PFC	Downward	Yes
Bud Brown Spring	18 July 2018	FAR	Downward	No
Duckweed Spring	17 Sept 2019	PFC	Downward	No
East Valley View Springs	24 Sept 2019	PFC	Upward	No
Hillside Spring	17 Sept 2019	PFC	Not Apparent	No
Juniper Spring	17 Sept 2019	FAR	Upward	No
Little Hat Mtn #3	11 Jan 2018	FAR	Not Apparent	No
Little Tuledad Canyon Spring	17 Sept 2019	PFC	Downward	No
Middle Valley View Spring	24 Sept 2019	PFC	Upward	No
North Valley View Spring	24 Sept 2019	PFC	Upward	No
Rosebud Complex	8 July 2018	NF	Downward	No
Sandstone Spring	24 Sept 2019	FAR	Downward	Yes
Steep Seep	17 Sept 2019	FAR	Downward	No
Unknown Spring (Meadow Reach)	8 Oct 2019	FAR	Downward	No
Unknown Spring (Spring Reach)	8 Oct 2019	PFC	Downward	No
Upper Ant Spring	24 Sept 2019	PFC	Not Apparent	No

West Valley View Springs Segment 1	24 Sept 2019	FAR	Not Apparent	No
West Valley View Springs Segment 2	24 Sept 2019	FAR	Downward	No

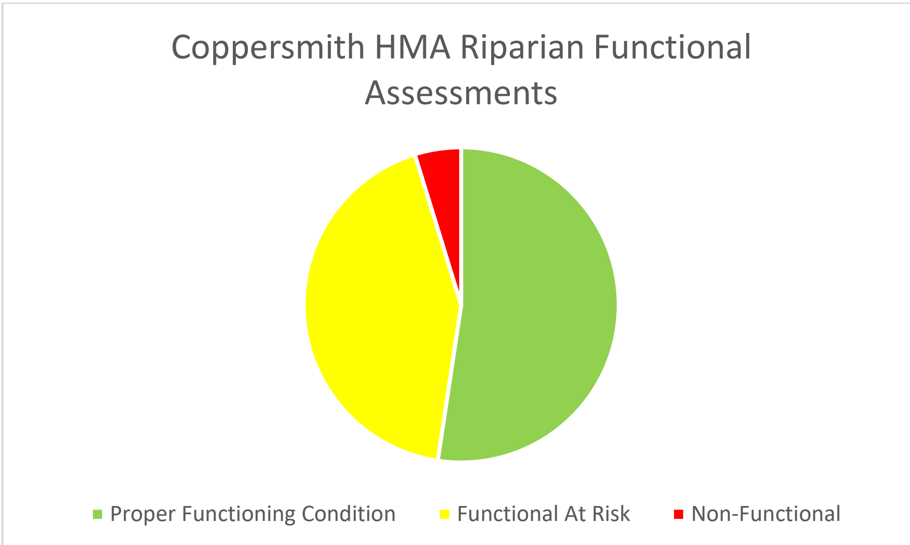

Figure I-10. Riparian functional assessments within the Coppersmith HMA.

The Coppersmith HMA has a variety of water sources including wells and pit reservoirs, with the majority being lotic and lentic systems. In general, this HMA has plentiful and well-distributed water sources, however on dry years, the lakes, reservoirs, and smaller seeps and springs would go dry. During these times, livestock and wild horses would concentrate on a limited number of perennial watering sites, which are primarily privately owned.

Most riparian system within the Coppersmith HMA show heavy past and current livestock and wild horse use. Many of these springs have been developed and excluded with off-site water provided. Several larger riparian exclosures have been established to protect riparian ecosystem function. These excluded riparian areas were once severely degraded and are now in various stages of recovery.

Figure I-11. A good diversity of riparian vegetation is present within this system's potential plant community. The channel is well-armored with rock and is able to withstand and resist physical alteration caused by livestock and wild horse use. Ant Spring (Outside Exclosure) was rated as Proper Functioning Condition.

Proper Functioning Condition

Figure I-12. Middle Valley View Springs is recovering from historical overuse and degradation. Although current livestock and wild horse use is evident, minimal physical alteration is occurring. The riparian area is expanding, and hydrologic processes are healing. Middle Valley View Spring was rated as Proper Functioning Condition.

Ant Spring consists of a small spring exclosure, headbox and trough development, and riparian drainage outside the exclosure. Inside and outside the exclosure were both assessed as PFC. The spring head and riparian area are well armored with rocks. Light grazing and hoof action was observed; however, the system is resistant to disturbances and resilient to disturbances that do occur. Although altered, the system appears to be slightly expanding in length and has almost reached its potential extent.

The Valley View Complex is a system of seeps and springs located in the northwestern portion of the Coppersmith HMA. East Valley View Spring, Middle Valley View Spring, North Valley View Spring, and Upper Ant Spring were rated as Proper Functioning Condition.

Figure I-13. Nonfunctional, deteriorating trough that has formed a new "spring head" from the developed Bird Bath Spring. The system is functioning to an extent within its altered potential.

These systems and their hydrologic processes are beginning to heal from historical overgrazing. Hydric vegetation is abundant in good diversity and age classes and OBL and FACW species are reestablishing and replacing upland species. Hoof action is present, but minimal and historical hummocks are revegetating. These springs are expanding or have reached their potential.

Figure I-14. Although a couple indicators of impairment (hoof action, bank shearing, and downcutting) were noted, a PFC rating was given because these impairments were small scale and are not currently significantly affect the overall hydrologic function of the spring. Unknown Spring and Meadow (Spring Reach) was rated PFC-Mid.

Bird Bath Spring is an altered system that was rated as PFC-Low with a downward trend. The spring source is protected within a riparian exclosure; however, all water is captured within the headbox and is diverted to a nonfunctional trough. Historical conditions are disappearing within the exclosure, and upland species are encroaching. A riparian area has developed below the deteriorating trough and all hydrologic processes have moved from the original spring source. Riparian characteristics are currently functioning, however, continued use from livestock and wild horses would further deteriorate this system.

Four springs were assessed as PFC-Mid to Low. Hillside Spring, Unknown Spring and Meadow (Spring Reach), Duckweed Spring, and Little Tuledad Canyon Spring are natural systems with most functions intact. These springs have high vegetative diversity and age classes for maintenance, recovery, and stability. Rock armored spring heads and riparian areas add to the structural stability. Despite being located on a gradient, these springs support primarily sheet flow and are not severely channelized (except the upper 1/3 of Little Tuledad Canyon Spring). Degraded water quality, small head cuts, hummocking, hoof action, hoof shearing, bank incision, and soil compaction were observed in one or all of these systems. These impairments are small scale and do not currently represent the majority of these systems. However, since the impairments are present, these systems are at high risk for further degradation with persistent use from livestock and wild horses.

Functional - At Risk

Figure I-15. Still considered proper functioning, Duckweed Spring is on the edge of becoming Functional-At-Risk. Excessive hoof action is leading to increased soil compaction, bank shearing and incision, and altered flow patterns. Duckweed Spring was rated PFC-Low with a downward trend.

Figure I-16. In addition to Phase 1 juniper encroachment dewatering the available groundwater, roads and hummocking are causing the riparian area to shrink and are redirecting flow away from the historical reach. West Valley View Spring (Segment 2) was rated as FAR-Low with a downward trend.

Nine riparian areas were rated as FAR within the Coppersmith HMA. Juniper Seep, Little Hat Mtn #3, and West Valley View Spring (Segment 1) are small seeps currently in maintenance and recovery stages. These systems are slightly expanding or moving toward reaching potential extent. Moderate grazing from livestock and wild horses is apparent and these sites are currently being impaired by hoof action. This physical alteration is disturbing flow patterns; however old hummocks are repairing. Plant communities are diverse in composition and OBL and FACW species are being recruited and replacing upland herbaceous vegetation in some areas. Much of the riparian areas are stabilized by deep rooted species and armored by rock. Historic and recent juniper encroachment is occurring and is intensifying dewatering impacts on these hydric systems. Segment 2 of West Valley View Spring was assessed at a lower rating than Segment 1, due to physical barriers and excessive trampling altering the riparian extent and overland flow. Sandstone Spring, a developed spring with an exclosure, is shrinking and ecologically suffering from dewatering. Anthropogenic damming and water diversion is resulting in a loss of hydric characteristics. Unknown Spring and Meadow (Meadow Reach) is also degraded from diversions, but this impairment is coming from tramping, hoof action, hummocking, and overgrazing from livestock and wild horses. The riparian area remains saturated and wetland species are present, but it was noted that a protection fence would aid in the recovery of this spring. Steep Seep is a very small seep on a side slope surrounded by juniper. Current and historic land use practices have caused this system to trend downward to the resulting decimated site. With continued disturbance, this system would likely become nonfunctional. Bare Creek, contained within a large partially functional exclosure, is one of the few lotic systems in this HMA. Several functions in this system are partially intact, but numerous attributes are impaired, causing this system to be rated as FAR-Mid with a downward trend. Portions of this system are in balance with the landscape and are able to withstand disturbances, however with variable flow fluctuations, this system is experiencing decreased inundation periods, narrowing of the riparian extent, and encroachment of upland species. The majority of the system has ample diversity of OBL and FACW species present at varying age classes to maintain the system. However, the lower 40% of the reach has excessive stream incision and downcutting. Livestock and wild horse grazing and hoof action are intensifying these affects and contributing to bank shearing, erosion, and soil loss. Water quality is also a concern for the freshwater biology of the system as algal blooms are common and possible eutrophication is occurring.

Figure I-17. Steep Seep has been so overused that only a small circle of riparian vegetation remains with little to no standing water. Abundant erosion, deposition, and contiguous bare ground contribute to the Functional-At-Risk-Low rating.

Bud Brown Spring, a historically extensive complex of wet meadows, is contained within a large, nonfunctional riparian exclosure. This spring system was rated as FAR-Low with a downward trend due to the overall dewatering and shrinking of the riparian area. Hydric vegetative components are present, however OBL and FACW species are not dominant. Cattle, sheep, and wild horse grazing is a chronic pressure on this system, resulting in areas of excessive hoof action, bank shearing, and extensive bare ground. This is system is at high risk of becoming nonfunctional.

Figure I-18. The source for Bare Creek, Newland Reservoir, is privately owned and controlled**.** The unpredictable and fluctuating water availability in conjunction with bank shearing, downcutting, and soil loss results in a system that is unable to maintain all hydric characteristics. Areas of this system are armored with rocks which is mitigating some physical alterations occurring from livestock and wild horse grazing. Large algal blooms are present throughout the entire extent of the Creek. Bare Creek was rated as Functional-At-Risk-Mid.

Nonfunctional

Rosebud Complex, a large system of springs within the Bud Brown riparian exclosure, was rated as nonfunctional. Since the fence is not functional, excessive livestock and wild horse grazing is occurring. This disturbance coupled with a diminishing water table has intensified the dewatering of the system, channelization, soil erosion, sediment displacement, bank shearing, and continuous patches of bare ground. Upland encroachment has been occurring for some time, with bitterbrush becoming well-established within the riparian area.

Carter Reservoir HMA

Table I-4. Springs and their ratings for the Carter Reservoir HMA.

Spring	Date Completed	Rating	Apparent Trend	Protected
Clover Seep	8 Nov 2021	FAR	Downward	No
Crest Seep	8 Dec 2021	FAR	Downward	No
Hillside Seeps	24 May 2022	FAR	Downward	No
Meadow Seeps	24 May 2022	FAR	Downward	No
Peters Gulch Seeps	7 June 2022	FAR	Downward	No
Sand Creek	18 Nov 2021	FAR	Upwards	Partially

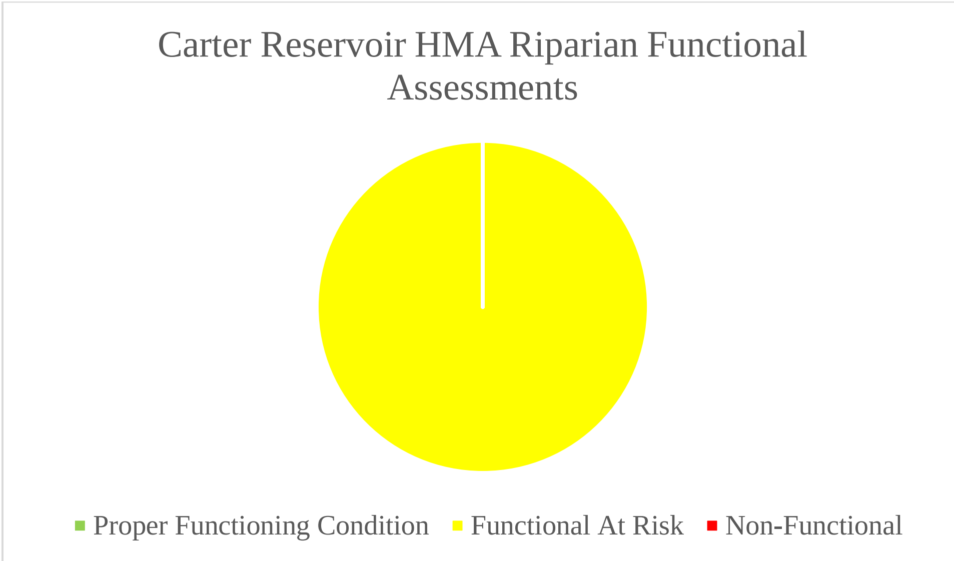

Figure I-19. Riparian functional assessments for the Carter Reservoir HMA.

In general, the Carter Reservoir HMA is lacking consistent water availability and distribution. Most of the water in this HMA is provided by pit reservoirs which are not assessed using the Proper Functioning Condition assessment. These are considered reliable water sources only during the early spring period on a good water year. There are two developed springs that provide off-site water, neither possess the characteristics necessary to be assessed. There are a few natural springs and seeps in the HMA, several are drying or have dried up. The majority of these springs are privately owned and controlled. Juniper encroachment into riparian areas of springs and seeps is a concern in this HMA. Juniper contributes to dewatering and lowering of water tables as taproots extend into riparian areas. There is one lotic system, Sand Creek, within the HMA. Water availability and condition of the Creek is subject to water diversion on private lands. There are four riparian protection exclosures along Sand Creek. Historically, these excluded riparian areas were severely degraded and are now in various stages of recovery. It should be noted that these areas would quickly return to a degraded state with prolonged and/or heavy disturbance, such as year-round grazing.

All the areas assessed are in varying stages of functioning at risk meaning they have lost critical functional abilities and may be close to becoming non-functional. When riparian areas have lost critical functions, often they become compromised. Many times, this leads to a dewatering of the system and loss of riparian habitat, possibly even the complete loss of a water source. Most of the riparian areas within the HMA are being excessively used and degraded by wild horses year-round and domestic livestock during the grazing season.

Proper Functioning Condition
No riparian areas in the Carter Reservoir HMA were rated as PFC.

Functional At Risk

All five lentic spring, seep systems and the one lotic system were rated as FAR in the Carter Reservoir HMA. FAR ratings mean that one or more indicators are lacking but it is not the same indicator for all systems. These systems are at risk for further loss of function if degradation continues.

Figure I-20. The encroachment of juniper and overall dewatering of this seep system has contributed to a loss of hydric vegetation communities and soils. Historical livestock and wild horse disturbances have created physical alterations intensifying these conditions. This seep complex is at risk for continued loss of ecological function. Hillside Seeps was rated as Functional - At Risk – Mid.

Hillside Seeps, a historically larger seep complex, was rated as FAR-Mid because of overall dewatering of the system, encroachment of juniper and upland species, and historical and current physical alteration. This system was noted to have a downward trend as the wetted riparian area is becoming increasingly unsaturated and loosing riparian characteristics. Wetland OBL and FACW species are present, however the extent and vigor of these species within the system is decreasing. Physical alteration including hoof shearing, hummocking, bare soil patches, and rills are present throughout the system. Some of these altered attributes are repairing and some are deteriorating with continued disturbance.

Peter’s Gulch Seeps is a seep drainage system highly dependent and variable on seasonal water supply. The water sources are located on privately owned lands and flow onto public lands with sufficient water. This system was rated as FAR-Mid with a downward trend as it is functioning but with several impairments. Concentrated domestic livestock and wild horse use has impaired the stability of the system through extreme hoof shearing, soil compaction, pugging, and trailing. These disturbances have resulted in and intensified conditions such as head cuts, bank alteration, channelization, loss of riparian vegetation, increased bare ground, soil erosion, sediment deposition, and encroachment of juniper, upland, and invasive species. With current conditions and continued cattle and horse use, impairment would continue to increase, and riparian functionality decrease.

Figure I-21. The headwaters of Peter's Gulch Seeps are on private property but are an important water source in the Carter Reservoir HMA. Lack of deep-rooted stabilizing vegetation, wetland obligates, elongation due to channelization and gradient of source, dewatering, and alterations such as head cuts, bank shearing, and hoof action all contributed to this Functional - At Risk – Mid rating.

Sand Creek is a natural perennial lotic system on public lands; however, water supply is unpredictable and dependent on private land use and water rights. The majority of the reach assessed is within four riparian exclosures with three water gaps open for livestock and wild horse use. The reach was rated as FAR-Mid.

Figure I-22. This photo is representative of the condition of Sand Creek within the riparian protection exclosures. Riparian vegetation exhibits high vigor, recovery, and recruitment. Exclusion of livestock and wild horse grazing is the main contributing factor to Sand Creek's recovery and rating of Functional - At Risk – Mid.

Within the exclosures, Sand Creek is generally in good condition and appears to be improving. Historic channel incision and high width/depth ratios are apparent, but overall, the stream is vertically stable and is in balance with the water and sediment being supplied by the drainage basin. Deep rooted plant communities exist in well-developed patches and the streambank, point bars, and adjacent terraces are actively being revegetated and replaced with OBL and FACW species as upland species slowly decline inside the exclosures. Many of these sections of the reach are expanding or have achieved potential extent. A woody component is a necessary stabilizer within this plant community, and although willow is present minimally it is absent in much of the reach. Anchored rock aids in the system's ability to withstand and dissipate energy during high flow events.

Figure I-23. This photo is representative of the condition of Sand Creek outside the riparian protection exclosures. Riparian vegetation exhibits low vigor and is declining due to continual disturbance from livestock and wild horses. Extreme hoof shearing, hummocking, and channel widening is apparent. Because exclosures protect much of Sand Creek, a Functional - At Risk – Mid rating was given.

Sections of the reach, not enclosed, experience heavy grazing from domestic livestock and wild horses. Natural processes, mainly herbaceous recruitment and soil stability are hampered by continual trailing within the channel. Trailing, hoof action, and over grazing are contributing to lateral instability. These sections are minimal in relation to the size of the reach, but because at least one of these attributes are present there is a high probability for further impairment.

Figure I-24. The excessive hoof action in the vegetated spring head and drainage has had major alteration to surface flow patterns. This disturbance has caused extreme compaction and erosion creating head cuts, exposed banks, and channelization. Clover Seep was rated as Functional - At Risk – Low.

Clover Seep and Crest Seep are unfenced, private springs and are extremely important year-round water sources within the Carter Reservoir HMA. Both springs were rated FAR-Low with a downward trend due to high ground disturbance, heavily compacted soils, and plant community composition. Although hydric vegetation communities are present, both systems lack well-established and extensive stabilizing species. Large, bare ground patches are well connected, and erosion has been and continues to be excessive. Extreme hoof action, head cuts, roads, and channelization affect the flow patterns. With continued disturbance to the highly compromised soils, these seeps are more prone to physical alteration and further degradation. Meadow Seeps was historically a large lentic complex and associated wet meadow. Due to natural desiccation and historic overgrazing, this complex no longer produces much surface water. Much topsoil has been lost from this site through excessive erosion and loss of the hydric plant community. Some FACW plants are scattered throughout the site, but upland species such as sagebrush and juniper have encroached due to lack of surface water. The team discussed a Nonfunctional rating but settled on a FAR-Low due to surface water at the spring head.

Nonfunctional
No riparian areas in the Carter Reservoir HMA were rated as nonfunctional.

Repeat RFAs

Of the 34 site visits included in this report, 11 of them were repeats from previous years. 18% (n = 2) were up in rating from a previous rating, 64% (n = 7) were static, meaning the rating had not changed, and 18% (n = 2) were down in rating from the previous rating.

Table I-5. Repeat RFAs in the Coppersmith and Buckhorn HMAs.

HMA	Spring	2009 EA	2023 EA	Trend
Coppersmith	Ant Spring Exclosure	PFC	PFC	Static
	Sandstone Spring	FAR	FAR	Downward
	Little Tuledad Canyon Spring	FAR	PFC	Upward
	Juniper Seep	FAR	FAR	Upward
	Bare Creek	FAR	FAR	Downward
	Bird Bath Spring	PFC	PFC	Downward
	Little Hat Mtn #3	FAR	FAR	Static
Buckhorn	Rowland Spring Exclosure	FAR	PFC	Static
	Rowland Spring (Outside)	FAR	FAR	Static
	Burnt Lake Spring Area	FAR	NF	Downward
	Willow Lake Springs	FAR	NF	Downward

Conclusion

The lack of riparian areas rated as PFC is concerning. Many higher ratings have a fenced off exclosure and provide off-site water outside the fence. That is not to say that grazing contradicts systems in PFC, there are examples of systems in Coppersmith HMA that both have grazing and are in very good condition. In fact, complete lack of grazing leads to a stagnation of vegetation communities and healing of hydrologic processes, as evidenced by systems in the Buckhorn and Carter Reservoir HMAs. Most of the riparian areas in this study are at risk for further impairment from chronic, excessive overuse. Many are completely lacking wetland obligate structural functional vegetation group. Without removal of the year-round disturbance from wild horses, these systems may be irreversibly damaged or completely lost.

Interdisciplinary Team

Table I-6. The interdisciplinary team members, position, and report contributions of the RFAs.

Name	Position	Responsibilities
Patrick Farris	Wild Horse and Burro Specialist	Project Lead
Kevin Kunkel	Assistant Field Manager, Rangeland Resources	ID team member
Jennifer Bonham	Rangeland Management Specialist	Vegetation, Hydrology, Soils
Allen LaGrange	Range Technician	Vegetation, Hydrology
Ethan Bonham	Range Technician	ID team member
Jennifer Mueller	Wildlife and Range Technician	ID team member
John Collins	Wildlife Biologist	ID team member
Devin Synder	Archaeologist	ID team member

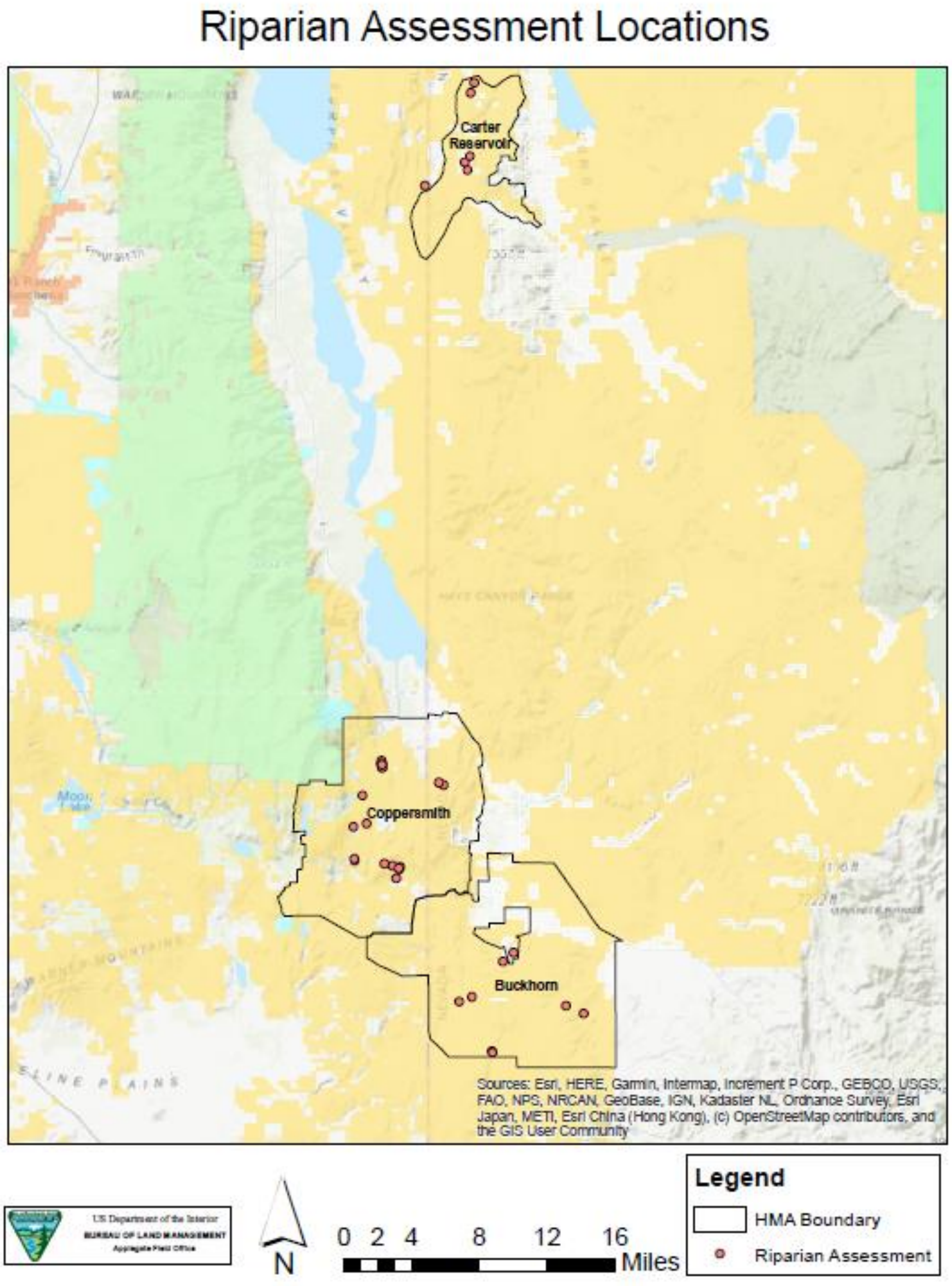

Figure I-25. The locations of the riparian areas that were assessed.

Appendix J. Map of Greater Sage-Grouse Habitat within the HMAs

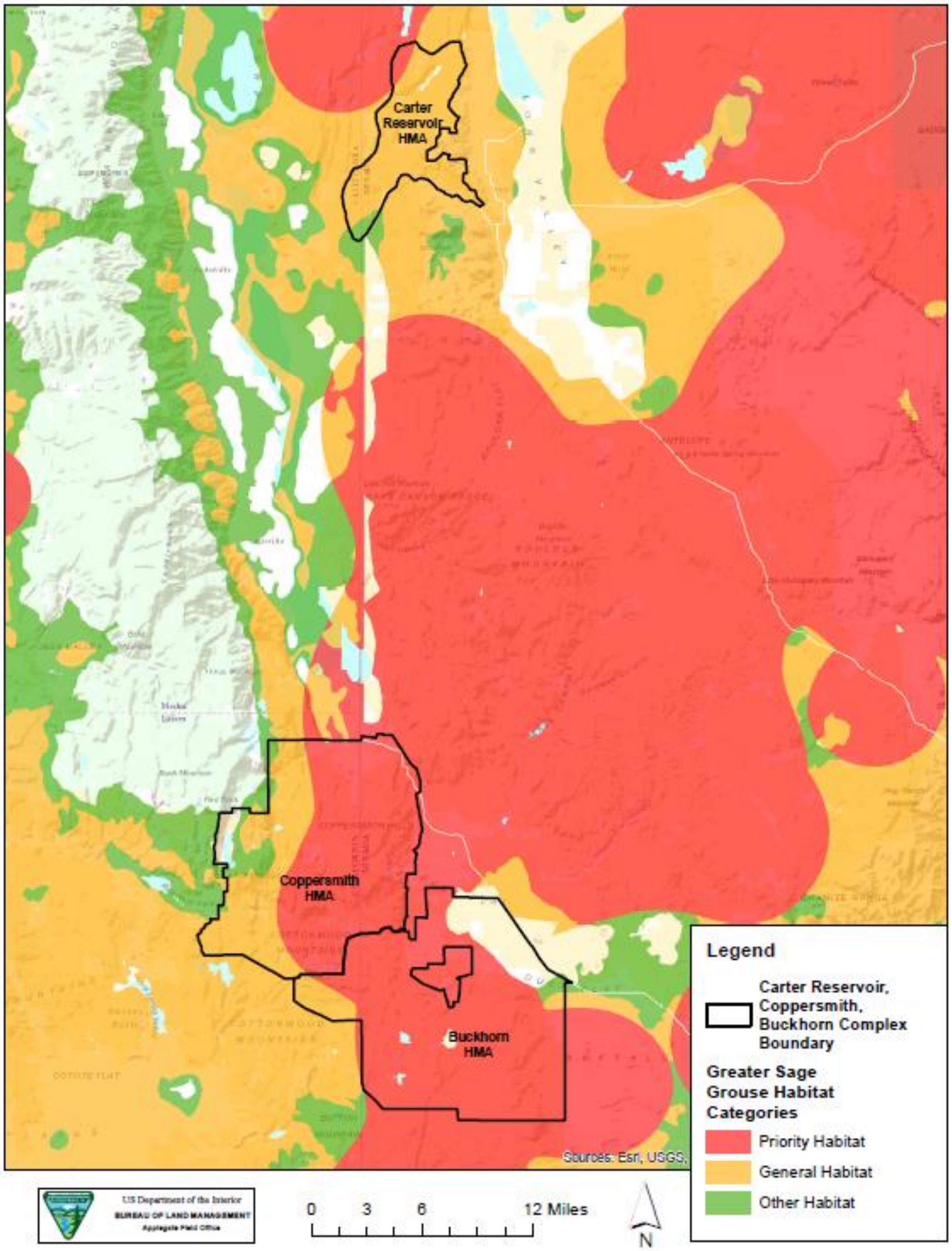

Figure J-1. Greater sage-grouse habitat within the Carter Reservoir, Buckhorn, and Coppersmith Herd Management Areas (HMAs).

Appendix K Historical Gather and Release Record from Carter Reservoir, Buckhorn, and Coppersmith HMAs

Tables L-1 through L-3 reflects the ongoing nature of the gather and removal cycle from the HMAs from early 1980's. This table was created from queries into the Wild Horse and Burro Program System (WH&BPS) database and internal BLM documents.

Table K-1. Carter Reservoir Herd Management Area historical gather data (Numbers included off HMA horses from Crooks Lake Area).

Year	Gathered	Estimated Not Gathered	Released	Removed
1985	31	10	13	18
1988	54 (19 Outside)	12	14	40
2003	213	12	14	197
2009	157 (100 Outside)	72 (40 Outside)	4	153

Table K-2. Buckhorn Herd Management Area historical gather data.

Year	Gathered	Estimated Not Gathered	Released	Removed
1983	No Record	15	49	No Record
1986	105	3	47	58
1989	87	23	35	52
1995	173	15	49	124
1997	68	57	22	48
2003	173	36	26	147
2009	236	19	42	194

Table K-3. Coppersmith Herd Management Area historical gather data.

Year	Gathered	Estimated Not Gathered	Released	Removed
1985	104	2	48	56
1986	43	24	26	17
1989	52	30	21	31
1995	161	31	39	122
1997	37	71	7	30
2005	194	65	0	194
2009	247	60	0	237

Appendix L. 2010 Individual HMA Genetic Reports

Genetic reports were available for Carter Reservoir, Buckhorn, and Coppersmith Herd Management Areas (HMAs).

Genetic Analysis of the Carter Reservoir HMA, CA

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The following is a report of the genetic analysis of the Carter Reservoir HMA, CA.

A few general comments about the genetic variability analysis based upon DNA microsatellites compared to blood typing. The DNA systems are more variable than blood typing systems, thus variation levels would be higher. Variation at microsatellite loci is strongly influenced by allelic diversity and changes in variation would be seen in allelic measures more quickly that at heterozygosity, which is why more allelic diversity measures are calculated. For mean values, there are a greater proportion of rare domestic breeds included in the estimates than for blood typing so relative values for the measures are lower compared to the feral horse values. As well, feral values are relatively higher because the majority of herds tested are of mixed ancestry which results in a relatively greater increase in heterozygosity values based upon the microsatellite data. There are no specific variants related to breed type, so similarity is based upon the total data set.

METHODS

A total of 60 samples were received by Texas A&M University, Equine Genetics Lab on November 17, 2009. DNA was extracted from the samples and tested for variation at 12 equine microsatellite (mSat) systems. These were *AHT*4, *AHT*5 *ASB*2, *ASB*17, *ASB*23, *HMS*3, *HMS*6, *HMS*7, *HTG*4, *HTG*10, *LEX*33, and *VHL*20. These systems were tested using an automated DNA sequencer to separate Polymerase Chain Reaction (PCR) products.

A variety of genetic variability measures were calculated from the gene marker data. The measures were observed heterozygosity *(Ho)* which is the actual number of loci heterozygous per individual; expected heterozygosity *(He)*, which is the predicted number of heterozygous loci based upon gene frequencies; effective number of alleles *(Ae)* which is a measure of marker system diversity; total number of variants *(TNV)*; mean number of alleles per locus (*MNA*); the number of rare alleles observed which are alleles that occur with a frequency of 0.05 or less (*RA*); the percent of rare alleles (*%RA*); and estimated inbreeding level *(Fis)* which is calculated as 1-*Ho/He*.

Genetic markers also can provide information about ancestry in some cases. Genetic resemblance to domestic horse breeds was calculated using Rogers' genetic similarity coefficient, *S.* This resemblance was summarized by use of a restricted maximum likelihood (RML) procedure.

RESULTS AND DISCUSSION

Variants present and allele frequencies are given in Table 1. No variants were observed which have not been seen in horse breeds. Table 2 gives the values for the genetic variability measures of the Carter Reservoir HMA herd. Also shown in Table 2 are values from a representative group of domestic horse breeds. The breeds were selected to cover the range of variability measures in domestic horse populations. Mean values for feral herds (based upon data from 126 herds) and mean values for domestic breeds (based upon 80 domestic horse populations) also are shown.

Mean genetic similarity of the Carter Reservoir HMA herd to domestic horse breed types are shown in Table 3. A dendrogram of relationship of the Carter Reservoir HMA herd to a standard set of domestic breeds is shown in Figure 1.

Genetic Variants: A total of 76 variants were seen in the Carter Reservoir HMA herd which is slightly above the mean for feral herds and below the mean for domestic breeds. A fairly high percentage of the variants are at risk of future loss due to low frequency in the population. This is reflected in the allelic diversity as represented by *Ae* which is below the average for feral herds while *MNA* is a little greater than the mean.

Genetic Variation: Genetic variation, as indicated by heterozygosity, in the Carter Reservoir HMA herd is well below the feral mean. *Ho* is essentially identical to *He* indicating the population is in genetic equilibrium.

Genetic Similarity: Overall values of similarity of the Carter Reservoir HMA herd with domestic breeds was about average for feral herds. Highest mean genetic similarity of the Carter Reservoir HMA herd was with North American Gaited breeds, followed closely by Oriental and Arabian breeds and the Light Racing and Riding breeds having almost the same *S.* As seen in Fig. 1, the Carter Reservoir HMA herd fits most closely to the Oriental group of breeds in a cluster that includes some of the Spanish breeds. This tree shows a good bit of distortion as with most trees involving feral herds. The most likely ancestry based upon the total analysis is of North American breeds.

SUMMARY

Genetic variability of this herd is slightly below the average for feral herds. The values related to allelic diversity are near the average while heterozygosity is relatively lower. Genetic similarity results suggest a herd with mixed ancestry that primarily is North American. The herd appears to be in genetic equilibrium which suggests recent stability of the population, although the high percentage of rare variants may indicate some slight gene flow into the population in the recent past.

RECOMMENDATIONS

Current variability levels are slightly low but not at a level that requires immediate action. The herd should continued to be monitored and tested again in about five years to see if variation levels have declined further.

Table L-1. Allele frequencies of genetic variants observed in Carter Reservoir HMA feral horse herd.

VHL20

I	J	K	L	M	N	O	P	Q	R	S
0.158	0.000	0.000	0.192	0.183	0.117	0.000	0.083	0.000	0.267	0.000

HTG4

I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.083	0.217	0.667	0.000	0.008	0.025	0.000	0.000

AHT4

H	I	J	K	L	M	N	O	P	Q	R
0.067	0.242	0.100	0.058	0.158	0.000	0.000	0.308	0.067	0.000	0.000

HMS7

I	J	K	L	M	N	O	P	Q	R
0.000	0.075	0.000	0.592	0.008	0.075	0.200	0.042	0.008	0.000

AHT5

I	J	K	L	M	N	O	P	Q	R
0.000	0.567	0.058	0.092	0.150	0.125	0.008	0.000	0.000	0.000

HMS6

I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.083	0.000	0.067	0.050	0.475	0.325	0.000	0.000

ASB2

B	I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.000	0.316	0.067	0.050	0.125	0.000	0.017	0.333	0.092

HTG10

H	I	J	K	L	M	N	O	P	Q	R	S	T
0.000	0.000	0.000	0.000	0.017	0.225	0.008	0.350	0.000	0.000	0.400	0.000	0.000

HMS3

H	I	J	K	L	M	N	O	P	Q	R	S
0.000	0.008	0.000	0.000	0.000	0.158	0.492	0.125	0.192	0.025	0.000	0.000

ASB17

D	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
0.000	0.017	0.033	0.000	0.000	0.058	0.000	0.000	0.067	0.417	0.008	0.000	0.000	0.400	0.000	0.000

ASB23

G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
0.000	0.000	0.025	0.058	0.308	0.350	0.000	0.000	0.000	0.000	0.000	0.000	0.025	0.000	0.234	0.000

LEX33

F	G	K	L	M	N	O	P	Q	R	S	T
0.000	0.025	0.108	0.075	0.401	0.000	0.083	0.008	0.158	0.075	0.000	0.067

Table L-2. Genetic variability measures.

	N	*Ho*	*He*	*Fis*	*Ae*	*TNV*	*MNA*	*Ra*	*%Ra*
CARTER RESERVOIR	**60**	**0.689**	**0.688**	**-0.001**	**3.48**	**76**	**6.33**	**20**	**0.263**
Cleveland Bay	47	0.610	0.627	0.027	2.934	59	4.92	16	0.271
American Saddlebred	576	0.740	0.745	0.007	4.25	102	8.50	42	0.412
Andalusian	52	0.722	0.753	0.041	4.259	79	6.58	21	0.266
Arabian	47	0.660	0.727	0.092	3.814	86	7.17	30	0.349
Exmoor Pony	98	0.535	0.627	0.146	2.871	66	5.50	21	0.318
Friesian	304	0.545	0.539	-0.011	2.561	70	5.83	28	0.400
Irish Draught	135	0.802	0.799	-0.003	5.194	102	8.50	28	0.275
Morgan Horse	64	0.715	0.746	0.041	4.192	92	7.67	33	0.359
Suffolk Punch	57	0.683	0.711	0.038	3.878	71	5.92	13	0.183
Tennessee Walker	60	0.666	0.693	0.038	3.662	87	7.25	34	0.391
Thoroughbred	1195	0.734	0.726	-0.011	3.918	69	5.75	18	0.261
Feral Horse Mean	126	0.716	0.710	-0.012	3.866	72.68	6.06	16.96	0.222
Standard Deviation		0.056	0.059	0.071	0.657	13.02	1.09	7.98	0.088
Minimum		0.496	0.489	-0.284	2.148	37	3.08	0	0
Maximum		0.815	0.798	0.133	5.253	96	8.00	33	0.400
Domestic Horse Mean	80	0.710	0.720	0.012	4.012	80.88	6.74	23.79	0.283
Standard Deviation		0.078	0.071	0.086	0.735	16.79	1.40	10.11	0.082
Minimum		0.347	0.394	-0.312	1.779	26	2.17	0	0
Maximum		0.822	0.799	0.211	5.30	119	9.92	55	0.462

Table L-3. Rogers' genetic similarity of the Carter Reservoir HMA feral horse herd to major groups of domestic horses.

	Mean *S*	Std	Minimum	Maximum
Light Racing and Riding Breeds	0.724	0.023	0.681	0.740
Oriental and Arabian Breeds	0.726	0.039	0.667	0.778
Old World Iberian Breeds	0.722	0.024	0.699	0.757
New World Iberian Breeds	0.708	0.041	0.640	0.766
North American Gaited Breeds	0.735	0.019	0.705	0.759
Heavy Draft Breeds	0.676	0.039	0.629	0.746
True Pony Breeds	0.683	0.022	0.665	0.716

Figure L-1. Partial RML tree of genetic similarity to domestic horse breeds.

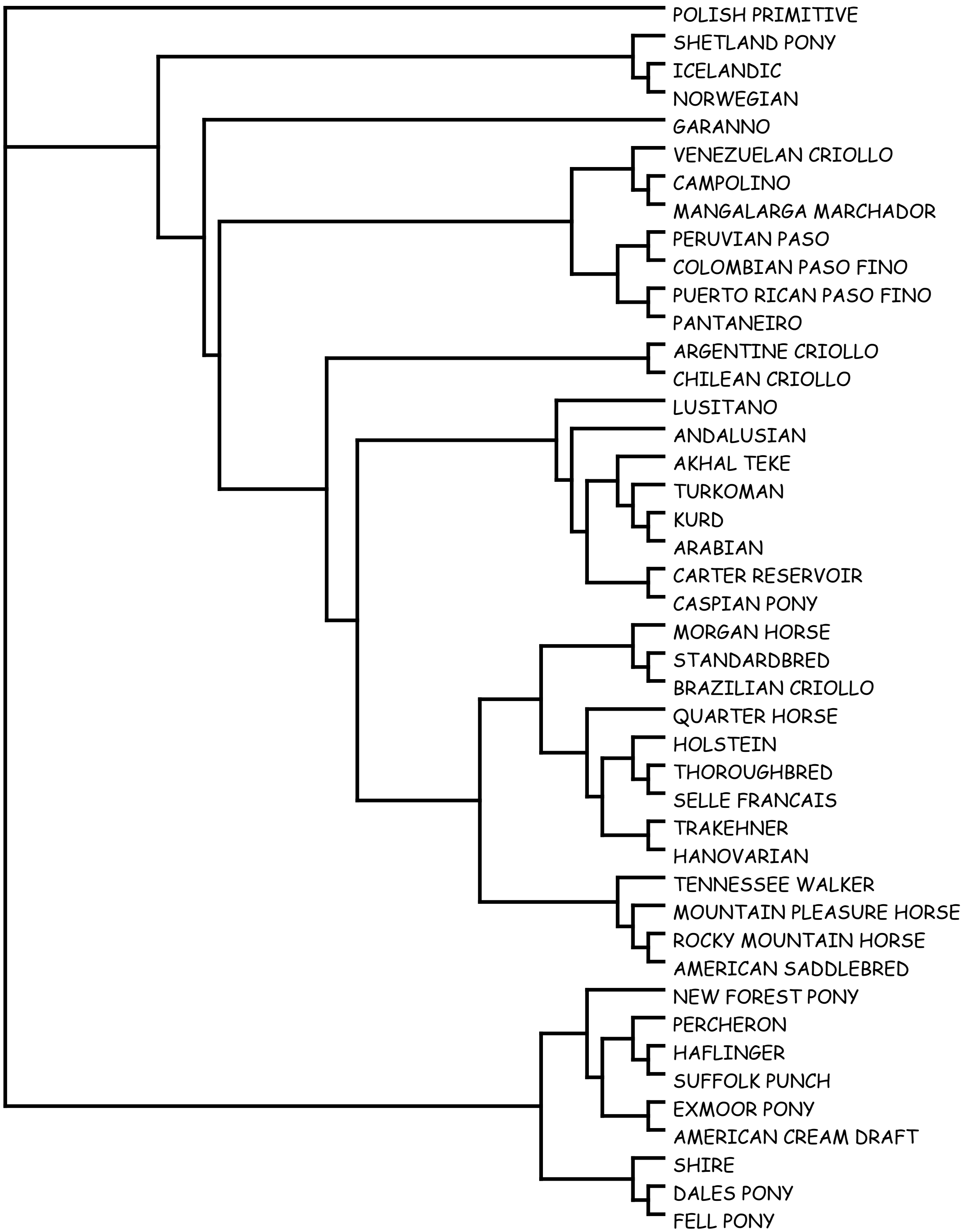

Table L-4. DNA data for the Carter Reservoir HMA, CA herd.

AID	AHT4	AHT5	ASB17	ASB2	ASB23	HMS3	HMS6	HMS7	HTG10	HTG4	LEX3	LEX33	VHL20
43170	JO	JJ	MN	KL	KL	PQ	MO	MO	MR	KL	HH	LM	LN
43171	OO	LM	NR	KQ	KU	MN	OO	LO	OR	MM	FF	MQ	IL
43172	IO	JJ	RR	KN	JK	NN	KK	LL	MR	MM	OO	MR	MR
43173	KO	JL	GN	KQ	KK	MN	MP	LL	MR	MM	FF	OQ	LR
43174	HL	JM	NR	MQ	LU	NP	OP	LO	OR	MM	HH	MM	IR
43175	IP	JL	NN	NN	KK	NP	KO	PP	MO	MM	OO	LR	IR
43176	KP	JL	RR	LQ	LU	NP	OP	OO	OO	MM	HH	MQ	RR
43177	HL	MM	FG	KP	LL	NP	OO	LQ	OO	MO	LL	LP	MP
43178	IO	JJ	RR	QQ	IU	MN	PP	OO	LO	MM	HH	MR	IR
43179	KL	JM	RR	MQ	LU	MN	OP	LN	OR	MM	FF	MM	IR
43180	JO	MN	NR	NQ	KU	MN	OO	LL	MR	MM	FF	MM	LL
43181	IO	JL	NN	KQ	KU	NO	KO	LP	MO	KM	OO	LL	MN
43182	IO	JJ	GN	KN	JK	NN	KK	LO	MR	MM	OO	RR	LM
43183	OP	JJ	NN	KQ	KL	NO	MO	LL	MR	LM	OO	MO	NR
43184	OO	JK	MR	QR	LS	MN	PP	LN	RR	MM	LL	MM	IR
43185	LL	JJ	NN	QR	LL	NP	OP	JL	OR	LM	LL	KT	MP
43186	IO	MN	NR	QR	LU	NP	NP	LL	RR	LM	LL	KQ	IR
43187	KO	JJ	NR	KK	KU	NN	OP	LP	OO	KM	OO	KO	IN
43188	JO	KM	MR	QR	U	MN	PP	JJ	MR	MM	LL	MM	IM
43189	IL	MN	MR	KQ	KL	NO	OP	LL	OR	LM	LL	KM	MN
43190	IL	MM	NN	QQ	LU	NP	OO	LO	OR	LM	HH	TT	IM
43191	JL	LM	MN	QR	U	MM	PP	JL	MR	LM	LL	MM	IR
43192	IO	JK	NR	RR	KU	NO	PP	JL	OR	MM	LL	MT	MR
43193	IO	JJ	MR	KR	LL	OO	PP	LN	RR	MM	LL	KT	MN
43194	IO	JN	NR	KQ	JL	NO	KO	LN	MR	LM	HH	MO	LP
43195	KP	JJ	JN	KQ	KL	PP	MO	LL	MR	KM	FH	MO	MR
43196	OO	JM	RR	KL	LU	NN	OO	OO	OR	MM	FF	MM	LP
43197	IJ	LN	MN	KQ	LU	MN	OP	JL	MO	LM	LO	MM	RR
43198	HI	JJ	NR	LQ	LL	NP	OO	LO	MR	LM	HH	KM	MP
43199	HO	JM	NR	QR	U	MN	NP	JL	MR	LM	FF	MQ	IR
43200	II	NN	GN	KQ	JL	OP	OO	LN	OR	LM	FO	MQ	LL
43201	IL	LM	NN	KR	LU	MP	OP	JL	MO	LL	LO	MM	RR
43202	OO	JJ	NR	KL	KL	NP	MO	LO	MR	MM	FF	MO	MP
43203	IP	LN	NN	KK	LU	NP	OO	LN	OO	LM	FO	KM	LR
43204	HL	JM	NR	QQ	KL	PP	OO	LL	OR	LM	LL	KQ	IN
43205	II	JJ	RR	KK	JK	NN	KP	LL	MR	LM	FO	MR	LR
43206	OO	JJ	RR	KN	KL	NN	OO	LO	MM	LM	FH	QR	LM
43207	HL	JJ	NN	KQ	LU	NP	NO	LL	OR	LM	FH	QQ	IM
43208	JO	JJ	NR	KN	KK	NO	KP	LP	MO	KM	HO	LO	MN
43209	IO	JJ	NR	LQ	LU	NO	NP	LL	OR	LM	FO	KM	IL
43210	LP	JJ	JR	QQ	LL	NO	OO	LN	OR	KM	HO	MM	RR
43211	IJ	JN	NR	NN	KL	NN	OP	LL	MM	LM	FH	MQ	LM
43212	KL	JJ	JR	KQ	KK	NQ	MP	LL	OR	KM	HO	MO	NR
43213	HO	JM	MR	QQ	LU	NP	OP	LL	RR	LM	LL	TT	MN
43214	HO	LN	NR	LM	JL	NP	OP	LO	OR	LM	HH	GQ	IP
43215	IO	JJ	NR	MN	KL	MN	OO	LO	MO	LM	FH	KQ	LR
43216	IO	JJ	NR	KM	KK	NP	OP	LL	OO	MM	FF	GR	LR
43217	IO	JN	NN	KN	KK	NN	MP	LL	MM	MM	FF	MR	LM
43218	IP	JJ	NR	QQ	KL	NO	OO	LL	OR	KM	HO	MM	MR
43219	IP	JJ	JN	KQ	LL	OP	OP	LL	OR	KL	HO	MM	NR
43220	LO	JN	JR	KK	KU	NN	NO	LL	RR	MM	FH	OT	IM
43221	LO	JN	RR	NQ	KL	MN	OP	NO	OR	MM	FO	MQ	LR
43222	IL	JJ	NR	KK	U	NO	NO	LN	OR	MM	FO	KQ	IR
43223	LL	KM	NR	QR	LS	MM	OP	LL	RR	MM	LL	KQ	MR
43224	IK	JN	JN	KK	KL	OQ	OP	LL	OO	MM	HO	LM	LN
43225	IO	LN	NR	LN	JK	MN	KO	OO	OR	LM	FH	GM	LP
43226	JO	JJ	JN	MN	II	IN	MP	LL	OO	MP	FF	LQ	NN
43227	LO	JJ	RR	KQ	LU	NN	OP	OO	OR	MM	FF	MQ	LR

Genetic Analysis of the Buckhorn HMA, CA

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October 20, 2010

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The following is a report of the genetic analysis of the Buckhorn HMA, CA.

A few general comments about the genetic variability analysis based upon DNA microsatellites compared to blood typing. The DNA systems are more variable than blood typing systems, thus variation levels would be higher. Variation at microsatellite loci is strongly influenced by allelic diversity and changes in variation would be seen in allelic measures more quickly that at heterozygosity, which is why more allelic diversity measures are calculated. For mean values, there are a greater proportion of rare domestic breeds included in the estimates than for blood typing so relative values for the measures are lower compared to the feral horse values. As well, feral values are relatively higher because the majority of herds tested are of mixed ancestry which results in a relatively greater increase in heterozygosity values based upon the microsatellite data. There are no specific variants related to breed type, so similarity is based upon the total data set.

METHODS

A total of 31 samples were received by Texas A&M University, Equine Genetics Lab on January 8, 2010. DNA was extracted from the samples and tested for variation at 12 equine microsatellite (mSat) systems. These were *AHT*4, *AHT*5 *ASB*2, *ASB*17, *ASB*23, *HMS*3, *HMS*6, *HMS*7, *HTG*4, *HTG*10, *LEX*33, and *VHL*20. These systems were tested using an automated DNA sequencer to separate Polymerase Chain Reaction (PCR) products.

A variety of genetic variability measures were calculated from the gene marker data. The measures were observed heterozygosity *(Ho)* which is the actual number of loci heterozygous per individual; expected heterozygosity *(He)*, which is the predicted number of heterozygous loci based upon gene frequencies; effective number of alleles *(Ae)* which is a measure of marker system diversity; total number of variants *(TNV)*; mean number of alleles per locus (*MNA*); the number of rare alleles observed which are alleles that occur with a frequency of 0.05 or less (*RA*); the percent of rare alleles (*%RA*); and estimated inbreeding level *(Fis)* which is calculated as 1-*Ho/He*.

Genetic markers also can provide information about ancestry in some cases. Genetic resemblance to domestic horse breeds was calculated using Rogers' genetic similarity coefficient, *S.* This resemblance was summarized by use of a restricted maximum likelihood (RML) procedure.

RESULTS AND DISCUSSION

Variants present and allele frequencies are given in Table 1. No variants were observed which have not been seen in horse breeds. Table 2 gives the values for the genetic variability measures of the Buckhorn HMA herd. Also shown in Table 2 are values from a representative group of domestic horse breeds. The breeds were selected to cover the range of variability measures in domestic horse populations. Mean values for feral herds (based upon data from 126 herds) and mean values for domestic breeds (based upon 80 domestic horse populations) also are shown.

Mean genetic similarity of the Buckhorn HMA herd to domestic horse breed types are shown in Table 3. A dendrogram of relationship of the Buckhorn HMA herd to a standard set of domestic breeds is shown in Figure 1.

Genetic Variants: A total of 77 variants were seen in the Buckhorn HMA herd which is below the mean for feral herds and well below the mean for domestic breeds. Of these, 16 had frequencies below 0.05. This percentage of variants at risk of future loss is slightly below average. Allelic diversity as represented by *Ae* is above the average for feral herds as is *MNA*.

Genetic Variation: Genetic variation, as indicated by heterozygosity, in the Buckhorn HMA herd is high and *Ho* is exceptionally high. *Ho* is much higher than *He*. This pattern is frequently associated with recent population bottlenecks (restrictions in population size).

Genetic Similarity: Overall similarity of the Buckhorn HMA herd to domestic breeds was about average for feral herds. Highest mean genetic similarity of the Buckhorn HMA herd was with Light Racing and Riding breeds, followed very closely by the North American Gaited breeds. Both groups of Iberian breeds also had fairly high values. As seen in Fig. 1, the Buckhorn HMA herd fits within a cluster that includes several South American Criollo breeds. This could be an indication of some Spanish ancestry although the herd is most likely of a mixed origin.

SUMMARY

Genetic variability of this herd is somewhat high based upon allelic diversity, and *He* values while *Ho* is quite high. The differences in the measures of heterozygosity could be an indication of a past reduction in population size. This would likely have occurred within in time period from about 25 to 50 years ago, assuming that there has been no introduction of individuals into the herd since the possible bottleneck. It is not likely to have been further back that this based upon the allelic diversity levels and a more recent reduction would probably not be reflected in heterozygosity levels. These results are in contrast to those reported for horses sampled in 2003 and tested using blood type systems. In this case heterozygosity levels were essentially the same. It does remain possible that there was a past population bottleneck that had not yet influenced heterozygosity one generation ago, however, the differences are not clearly evident. Variability levels were high in 2003. Genetic similarity results suggest a herd with mixed ancestry that primarily is North American but with possible Spanish heritage as well. The results are consistent with the ideal that this herd has Spanish ancestry with strong influence from cavalry remount horses at a later time.

RECOMMENDATIONS

Current variability levels are high enough that no action is needed at this point, but this herd should be monitored closely due to the numbers of animals maintained at this HMA and the differences in results between the two sampling periods. A third sample in another four or five years may resolve the differences.

Table L-5. Allele frequencies of genetic variants observed in Buckhorn HMA feral horse herd.

VHL20

I	J	K	L	M	N	O	P	Q	R	S
0.258	0.000	0.000	0.097	0.290	0.177	0.016	0.081	0.000	0.081	0.000

HTG4

I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.274	0.016	0.565	0.000	0.048	0.097	0.000	0.000

AHT4

H	I	J	K	L	M	N	O	P	Q	R
0.274	0.000	0.305	0.065	0.081	0.000	0.065	0.129	0.081	0.000	0.000

HMS7

I	J	K	L	M	N	O	P	Q	R
0.000	0.129	0.000	0.388	0.290	0.129	0.032	0.000	0.032	0.000

AHT5

I	J	K	L	M	N	O	P	Q	R
0.016	0.242	0.065	0.048	0.065	0.241	0.323	0.000	0.000	0.000

HMS6

I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.097	0.113	0.210	0.000	0.161	0.419	0.000	0.000

ASB2

B	I	J	K	L	M	N	O	P	Q	R
0.000	0.113	0.000	0.113	0.016	0.371	0.177	0.097	0.000	0.032	0.081

HTG10

H	I	J	K	L	M	N	O	P	Q	R	S	T
0.000	0.000	0.000	0.000	0.210	0.290	0.000	0.097	0.032	0.016	0.355	0.000	0.000

HMS3

H	I	J	K	L	M	N	O	P	Q	R	S
0.000	0.210	0.000	0.000	0.000	0.210	0.097	0.112	0.242	0.048	0.081	0.000

ASB17

D	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
0.000	0.000	0.000	0.000	0.016	0.000	0.145	0.000	0.145	0.339	0.000	0.000	0.032	0.291	0.032	0.000

ASB23

G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
0.016	0.000	0.000	0.194	0.194	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.386	0.081	0.129	0.000

LEX33

F	G	K	L	M	N	O	P	Q	R	S	T
0.000	0.000	0.065	0.434	0.000	0.000	0.242	0.000	0.097	0.081	0.081	0.000

Table L-6. Genetic variability measures.

	N	*Ho*	*He*	*Fis*	*Ae*	*TNV*	*MNA*	*Ra*	*%Ra*
BUCKHORN HMA	**31**	**0.806**	**0.749**	**-0.076**	**4.15**	**77**	**6.42**	**16**	**0.208**
Cleveland Bay	47	0.610	0.627	0.027	2.934	59	4.92	16	0.271
American Saddlebred	576	0.740	0.745	0.007	4.25	102	8.50	42	0.412
Andalusian	52	0.722	0.753	0.041	4.259	79	6.58	21	0.266
Arabian	47	0.660	0.727	0.092	3.814	86	7.17	30	0.349
Exmoor Pony	98	0.535	0.627	0.146	2.871	66	5.50	21	0.318
Friesian	304	0.545	0.539	-0.011	2.561	70	5.83	28	0.400
Irish Draught	135	0.802	0.799	-0.003	5.194	102	8.50	28	0.275
Morgan Horse	64	0.715	0.746	0.041	4.192	92	7.67	33	0.359
Suffolk Punch	57	0.683	0.711	0.038	3.878	71	5.92	13	0.183
Tennessee Walker	60	0.666	0.693	0.038	3.662	87	7.25	34	0.391
Thoroughbred	1195	0.734	0.726	-0.011	3.918	69	5.75	18	0.261
Feral Horse Mean	126	0.716	0.710	-0.012	3.866	72.68	6.06	16.96	0.222
Standard Deviation		0.056	0.059	0.071	0.657	13.02	1.09	7.98	0.088
Minimum		0.496	0.489	-0.284	2.148	37	3.08	0	0
Maximum		0.815	0.798	0.133	5.253	96	8.00	33	0.400
Domestic Horse Mean	80	0.710	0.720	0.012	4.012	80.88	6.74	23.79	0.283
Standard Deviation		0.078	0.071	0.086	0.735	16.79	1.40	10.11	0.082
Minimum		0.347	0.394	-0.312	1.779	26	2.17	0	0
Maximum		0.822	0.799	0.211	5.30	119	9.92	55	0.462

Table L-7. Rogers' genetic similarity of the Buckhorn HMA feral horse herd to major groups of domestic horses.

	Mean *S*	Std	Minimum	Maximum
Light Racing and Riding Breeds	0.789	0.029	0.753	0.830
Oriental and Arabian Breeds	0.765	0.036	0.721	0.822
Old World Iberian Breeds	0.773	0.026	0.750	0.817
New World Iberian Breeds	0.770	0.016	0.742	0.793
North American Gaited Breeds	0.777	0.023	0.744	0.813
Heavy Draft Breeds	0.696	0.055	0.638	0.782
True Pony Breeds	0.724	0.036	0.681	0.773

Figure L-2. Partial RML tree of genetic similarity to domestic horse breeds.

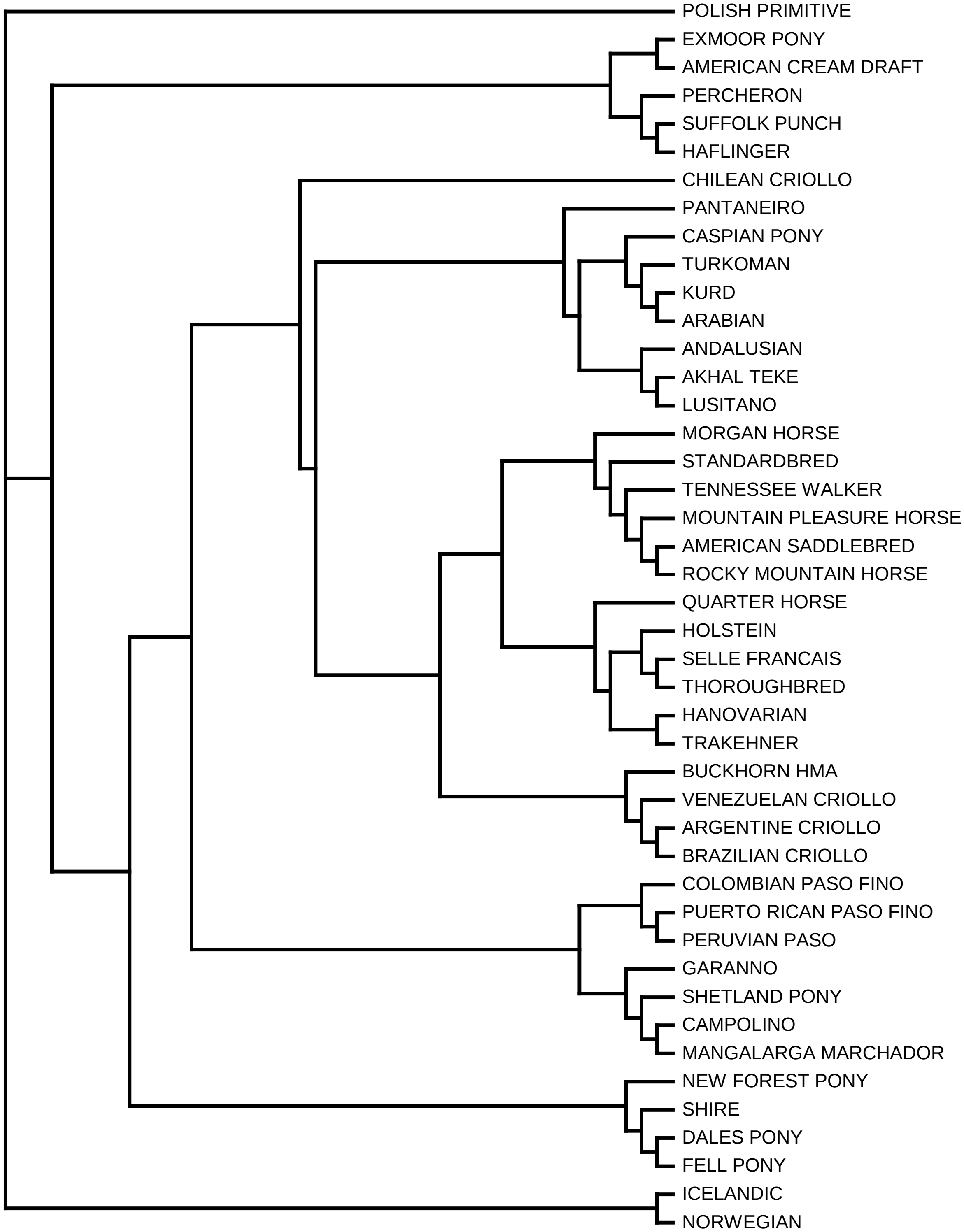

Table L-8. DNA data for the Buckhorn HMA, CA herd.

AID	VHL20	HTG4	AHT4	HMS7	AHT5	HMS6	ASB2	HTG10	HMS3	ASB17	ASB23	LEX33	LEX3
43917	MN	KM	JN	LN	KO	PP	IM	LM	IM	QR	ST	LQ	MM
43918	LM	MM	HJ	MM	JO	OP	MN	LM	NP	NN	JT	LO	LL
43919	LM	MP	HJ	JN	NO	OP	MO	LM	IM	NN	JS	LS	LL
43920	IM	KK	HJ	LM	JO	MM	QR	MO	OO	MR	JJ	LQ	LL
43921	IM	MM	HH	LM	JN	PP	MN	MR	PR	NR	JS	LL	MM
43922	MR	KO	LP	MN	OO	OP	IR	RR	IP	KM	KT	LO	LL
43923	MP	KM	HL	LM	JN	LP	KM	MR	MP	KN	JS	LO	MM
43924	IR	MM	JJ	OQ	JO	KP	IM	LO	IN	NR	KS	LO	MM
43925	IN	LM	HP	LL	NN	OO	MO	MO	OP	NR	SS	OR	NN
43926	IN	MM	HJ	LM	JK	LM	KM	LR	NP	KN	KS	OO	LL
43927	IN	KK	HK	LM	NO	MP	KO	LM	IQ	NR	SU	QS	LM
43928	IP	MM	JO	LL	NO	OP	KO	MR	MN	KN	SS	LO	LM
43929	NO	KK	JN	LM	KL	KM	MM	MR	MR	KN	ST	LL	HP
43930	MR	MP	HP	LN	OO	PP	MR	MR	PP	KN	JK	LR	FF
43931	IM	MM	HJ	MN	JN	PP	NN	MR	IN	MS	KS	LL	IL
43932	IM	KM	KL	LM	NO	MM	MR	LR	OR	RR	KU	LR	HM
43933	II	KO	JO	LN	JJ	MP	KN	MR	IP	MR	SS	KO	MP
43934	IM	MM	JO	LL	JN	LP	MN	RR	MP	RR	JJ	LR	LM
43935	PR	MM	HP	OQ	JL	KK	IN	OP	OP	KR	GK	KQ	OP
43936	IL	MP	HK	JL	OO	MP	IM	LL	MR	NR	SU	LL	MM
43937	IP	KK	JO	JM	JN	PP	MQ	OR	IP	MR	SS	KO	MO
43938	MN	KK	NO	JL	MO	LO	KM	QR	IM	MR	KU	KR	LM
43939	LN	KM	JJ	LL	MN	MP	NO	MR	II	NN	KS	LS	LM
43940	MN	MM	JO	JM	JO	KP	MM	MP	MP	MN	SU	LO	LP
43941	LN	MM	JO	JN	JK	LM	MN	LR	IN	KN	KS	LL	LM
43942	MN	KM	JN	MN	MO	OP	IM	LR	MP	QR	JT	OQ	MN
43943	MP	MM	LL	JL	IJ	LL	KO	MO	PQ	IK	SU	LS	MN
43944	MR	MO	HP	LM	LO	KM	LM	MR	MO	MR	JK	OQ	MO
43945	IM	MP	KO	JM	NO	MP	MR	LR	OR	NR	SU	LO	HM
43946	LM	PP	HH	LM	NO	OP	IM	LR	MQ	NN	JS	LS	MM
43947	IN	MM	HJ	LM	MN	OP	NN	MR	IM	MS	KU	LO	LL

Genetic Analysis of the Coppersmith HMA, CA

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The following is a report of the genetic analysis of the Coppersmith HMA, CA.

A few general comments about the genetic variability analysis based upon DNA microsatellites compared to blood typing. The DNA systems are more variable than blood typing systems, thus variation levels would be higher. Variation at microsatellite loci is strongly influenced by allelic diversity and changes in variation would be seen in allelic measures more quickly that at heterozygosity, which is why more allelic diversity measures are calculated. For mean values, there are a greater proportion of rare domestic breeds included in the estimates than for blood typing so relative values for the measures are lower compared to the feral horse values. As well, feral values are relatively higher because the majority of herds tested are of mixed ancestry which results in a relatively greater increase in heterozygosity values based upon the microsatellite data. There are no specific variants related to breed type, so similarity is based upon the total data set.

METHODS

A total of 53 samples were received by Texas A&M University, Equine Genetics Lab on November 17, 2009. DNA was extracted from the samples and tested for variation at 12 equine microsatellite (mSat) systems. These were *AHT*4, *AHT*5 *ASB*2, *ASB*17, *ASB*23, *HMS*3, *HMS*6, *HMS*7, *HTG*4, *HTG*10, *LEX*33, and *VHL*20. These systems were tested using an automated DNA sequencer to separate Polymerase Chain Reaction (PCR) products.

A variety of genetic variability measures were calculated from the gene marker data. The measures were observed heterozygosity *(Ho)* which is the actual number of loci heterozygous per individual; expected heterozygosity *(He)*, which is the predicted number of heterozygous loci based upon gene frequencies; effective number of alleles *(Ae)* which is a measure of marker system diversity; total number of variants *(TNV)*; mean number of alleles per locus (*MNA*); the number of rare alleles observed which are alleles that occur with a frequency of 0.05 or less (*RA*); the percent of rare alleles (*%RA*); and estimated inbreeding level *(Fis)* which is calculated as 1-*Ho/He*.

Genetic markers also can provide information about ancestry in some cases. Genetic resemblance to domestic horse breeds was calculated using Rogers' genetic similarity coefficient, *S*. This resemblance was summarized by use of a restricted maximum likelihood (RML) procedure.

RESULTS AND DISCUSSION

Variants present and allele frequencies are given in Table 1. No variants were observed which have not been seen in horse breeds. Table 2 gives the values for the genetic variability measures of the Coppersmith HMA herd. Also shown in Table 2 are values from a representative group of domestic horse breeds. The breeds were selected to cover the range of variability measures in domestic horse populations. Mean values for feral herds (based upon data from 126 herds) and mean values for domestic breeds (based upon 80 domestic horse populations) also are shown.

Mean genetic similarity of the Coppersmith HMA herd to domestic horse breed types are shown in Table 3. A dendrogram of relationship of the Coppersmith HMA herd to a standard set of domestic breeds is shown in Figure 1.

Genetic Variants: A total of 76 variants were seen in the Coppersmith HMA herd which is slightly above the mean for feral herds and below the mean for domestic breeds. Of these, 26 had frequencies below 0.05 which is a very high percentage of variants at risk of future loss. Other measures of allelic diversity as represented by *Ae* also is below the average for feral herds while *MNA* is slightly higher than average.

Genetic Variation: Genetic variation, as indicated by heterozygosity, in the Coppersmith HMA herd is just below the feral mean. *Ho* is slightly higher than *He* but not significantly so.

Genetic Similarity: Overall similarity of the Coppersmith HMA herd to domestic breeds was somewhat low for a feral herd. Highest mean genetic similarity of the Coppersmith HMA herd was with the Light Racing and Riding breeds. No other breed group showed evidence of close similarity. As seen in Fig. 1, the Coppersmith HMA herd fits within a cluster of heavy draft breeds and two pony breeds. This does not likely reflect relationship but rather a lack of close relationship to any breed group and tree distortion. The most likely ancestry is of mixed breed origins.

SUMMARY

Genetic variability of this herd is difficult to interpret because the heterozygosity suggests genetic equilibrium while the high number of rare alleles suggest population mixing and the heterozygosity values seem low for the allele numbers. The genetic similarity values support a mixed ancestry for the herd but

perhaps this occurred several generations ago, and the population has now reached near equilibrium while allelic loss continues.

RECOMMENDATIONS

Current variability levels are high enough that no action is needed at this point, but the herd should be monitored and tested again in about five years. It is likely that loss of diversity would take place over the next few years due to the high percentage of alleles at low frequency. However, this is not certain, and variability could stabilize so that retesting would be needed.

Table L-9. Allele frequencies of genetic variants observed in Coppersmith HMA feral horse herd.

VHL20

I	J	K	L	M	N	O	P	Q	R	S
0.604	0.000	0.000	0.000	0.066	0.066	0.000	0.226	0.000	0.038	0.000

HTG4

I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.283	0.094	0.463	0.000	0.113	0.038	0.009	0.000

AHT4

H	I	J	K	L	M	N	O	P	Q	R
0.170	0.282	0.142	0.047	0.123	0.019	0.000	0.217	0.000	0.000	0.000

HMS7

I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.000	0.255	0.245	0.472	0.028	0.000	0.000	0.000

AHT5

I	J	K	L	M	N	O	P	Q	R
0.000	0.311	0.019	0.000	0.349	0.283	0.038	0.000	0.000	0.000

HMS6

I	J	K	L	M	N	O	P	Q	R
0.000	0.000	0.019	0.132	0.151	0.000	0.000	0.698	0.000	0.000

ASB2

B	I	J	K	L	M	N	O	P	Q	R
0.000	0.397	0.000	0.293	0.009	0.170	0.094	0.028	0.000	0.009	0.000

HTG10

H	I	J	K	L	M	N	O	P	Q	R	S	T
0.000	0.236	0.000	0.038	0.340	0.254	0.000	0.038	0.085	0.009	0.000	0.000	0.000

HMS3

H	I	J	K	L	M	N	O	P	Q	R	S
0.000	0.085	0.000	0.000	0.000	0.302	0.000	0.292	0.142	0.170	0.009	0.000

ASB17

D	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
0.000	0.085	0.000	0.000	0.009	0.057	0.132	0.038	0.019	0.028	0.075	0.198	0.000	0.094	0.265	0.000

ASB23

G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
0.009	0.000	0.000	0.312	0.019	0.283	0.000	0.000	0.000	0.000	0.000	0.245	0.066	0.000	0.066	0.000

LEX33

F	G	K	L	M	N	O	P	Q	R	S	T
0.000	0.000	0.019	0.330	0.009	0.189	0.028	0.000	0.379	0.047	0.000	0.000

Table L-10. Genetic variability measures.

	N	*Ho*	*He*	*Fis*	*Ae*	*TNV*	*MNA*	*Ra*	*%Ra*
COPPERSMITH	**53**	**0.708**	**0.703**	**-0.007**	**3.72**	**76**	**6.33**	**26**	**0.342**
Cleveland Bay	47	0.610	0.627	0.027	2.934	59	4.92	16	0.271
American Saddlebred	576	0.740	0.745	0.007	4.25	102	8.50	42	0.412
Andalusian	52	0.722	0.753	0.041	4.259	79	6.58	21	0.266
Arabian	47	0.660	0.727	0.092	3.814	86	7.17	30	0.349
Exmoor Pony	98	0.535	0.627	0.146	2.871	66	5.50	21	0.318
Friesian	304	0.545	0.539	-0.011	2.561	70	5.83	28	0.400
Irish Draught	135	0.802	0.799	-0.003	5.194	102	8.50	28	0.275
Morgan Horse	64	0.715	0.746	0.041	4.192	92	7.67	33	0.359
Suffolk Punch	57	0.683	0.711	0.038	3.878	71	5.92	13	0.183
Tennessee Walker	60	0.666	0.693	0.038	3.662	87	7.25	34	0.391
Thoroughbred	1195	0.734	0.726	-0.011	3.918	69	5.75	18	0.261
Feral Horse Mean	126	0.716	0.710	-0.012	3.866	72.68	6.06	16.96	0.222
Standard Deviation		0.056	0.059	0.071	0.657	13.02	1.09	7.98	0.088
Minimum		0.496	0.489	-0.284	2.148	37	3.08	0	0
Maximum		0.815	0.798	0.133	5.253	96	8.00	33	0.400
Domestic Horse Mean	80	0.710	0.720	0.012	4.012	80.88	6.74	23.79	0.283
Standard Deviation		0.078	0.071	0.086	0.735	16.79	1.40	10.11	0.082
Minimum		0.347	0.394	-0.312	1.779	26	2.17	0	0
Maximum		0.822	0.799	0.211	5.30	119	9.92	55	0.462

Table L-11. Rogers' genetic similarity of the Coppersmith HMA feral horse herd to major groups of domestic horses.

	Mean *S*	Std	Minimum	Maximum
Light Racing and Riding Breeds	0.719	0.022	0.680	0.741
Oriental and Arabian Breeds	0.682	0.027	0.652	0.721
Old World Iberian Breeds	0.703	0.020	0.675	0.724
New World Iberian Breeds	0.692	0.027	0.643	0.721
North American Gaited Breeds	0.681	0.024	0.639	0.701
Heavy Draft Breeds	0.659	0.051	0.582	0.722
True Pony Breeds	0.667	0.017	0.641	0.688

Figure L-3. Partial RML tree of genetic similarity to domestic horse breeds.

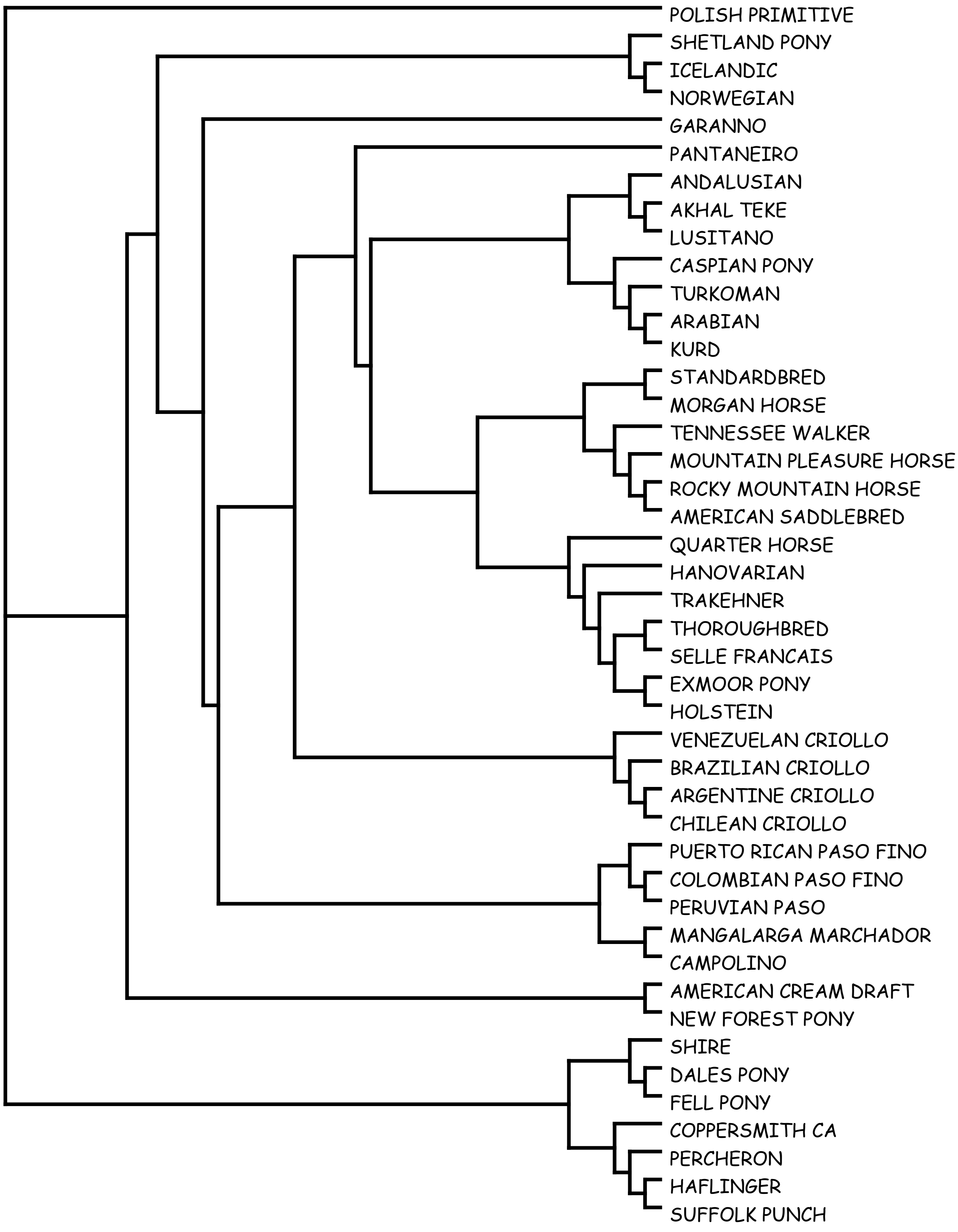

Table L-12. DNA data for the Coppersmith HMA, CA herd.

AID	AHT4	AHT5	ASB17	ASB2	ASB23	HMS3	HMS6	HMS7	HTG10	HTG4	LEX3	LEX33	VHL20
43228	OO	JM	LS	IN	LR	MQ	LM	MN	LP	MM	FF	NQ	II
43229	KL	MN	NS	II	JJ	MP	PP	LM	IK	LM	MM	QR	IN
43230	LO	JN	FR	KK	LL	MP	MP	LN	LM	KK	FF	LQ	IP
43231	IO	JJ	PR	IK	LR	MP	LM	LN	IL	LM	MM	LQ	IP
43232	IL	MO	KP	KK	JL	MO	MP	MN	IL	MM	FF	LQ	II
43233	HI	MM	PP	IK	RS	MO	PP	MM	IL	KO	LL	QQ	IP
43234	HI	JN	KP	IK	LU	MQ	PP	NN	IL	KO	JJ	LN	IN
43235	H	JM	PS	IM	SU	OO	PP	MN	IL	KM	LL	QQ	II
43236	IJ	JO	SS	IM	JL	OQ	PP	NN	LM	MO	FF	LN	II
43237	IJ	JN	FS	KM	JR	IM	PP	NN	MP	MO	FF	LN	IM
43238	KO	JJ	KP	II	JL	IQ	PP	LM	LM	KM	JJ	LQ	NP
43239	LL	JM	SS	KK	JR	OP	LP	LM	MP	MM	MM	MQ	PP
43240	OO	MN	FP	MN	JR	MO	PP	NN	LM	KM	FF	LN	IR
43241	KO	MN	KN	II	JR	MP	PP	LN	KL	LM	MM	LR	IN
43242	HI	JJ	OP	KM	RU	OQ	PP	NO	II	KO	JJ	LR	II
43243	HI	JM	KK	IM	JR	IO	KP	NN	MQ	MM	LL	NQ	IN
43244	IO	MN	PS	IN	LR	MO	MP	NN	IL	MM	MM	LQ	IP
43245	JJ	JK	KM	KM	SS	PR	PP	LM	LM	MQ	FF	LL	NR
43246	OO	NN	SS	KM	LL	IQ	MM	MN	II	MM	MM	LQ	II
43247	IO	JN	PR	IM	JJ	MO	MP	LN	IM	MM	LL	NO	IP
43248	IO	JN	LP	II	JR	MP	LP	NN	LL	LP	MM	QQ	IP
43249	IL	MN	FS	KM	LR	IP	LP	LO	IL	KP	MM	LQ	IP
43250	JL	MM	JJ	IK	JL	IQ	LP	NN	LP	KK	LL	LN	II
43251	H	MN	KO	IN	JR	MO	PP	NN	LM	KM	MM	LN	IM
43252	HO	MN	FS	IN	JJ	MO	PP	LN	LP	KM	MM	LQ	PR
43253	HL	JM	FO	IK	LR	QQ	LP	MN	IO	KM	FF	LQ	IP
43254	IO	JN	KP	II	LL	MM	PP	LN	MM	KK	FM	LO	II
43255	OO	JN	PS	KM	LL	OQ	MP	MN	IL	MM	FM	QQ	IP
43256	HO	JM	LO	II	JL	MM	LL	NN	IM	KM	FF	NN	II
43257	II	NN	KS	KN	JR	MQ	PP	NN	MM	KO	FF	LL	II
43258	HI	JM	JK	IN	JU	MO	PP	LN	MP	KO	FM	LN	II
43259	II	JN	RS	KM	JR	OP	LM	LN	LL	LM	FM	NQ	II
43260	KL	JN	NS	IO	JS	MP	PP	LM	LM	LM	JM	QR	IM
43261	IO	JM	PS	II	LU	MO	PP	LM	MM	MM	MM	LQ	IP
43262	LO	NN	LS	KN	LR	MP	PP	LN	LP	KP	FF	QQ	IM
43263	HJ	MN	JO	IN	JJ	IQ	PP	NN	LP	KM	LM	LN	II
43264	HJ	MM	RR	MO	KK	IM	LP	LL	OO	KM	FO	LL	MP
43266	II	MM	SS	IK	RR	OO	PP	LM	II	KM	FM	NQ	II
43267	HI	JN	FP	IK	JJ	OP	PP	NN	LL	KL	MM	NQ	PP
43268	JO	JM	KS	IK	JR	OQ	PP	MM	IM	LO	FF	LN	IP
43269	MM	JO	IM	IK	LL	MM	LM	LN	KP	MM	PP	KO	IR
43270	IJ	JM	OS	KK	LR	MO	PP	LN	IL	KO	FL	NQ	II
43271	JO	KN	FS	LQ	GL	OP	KP	LM	IO	KL	NN	LQ	IM
43272	JL	MM	OP	IK	JL	OO	PP	MM	IM	KO	FL	QQ	II
43273	HK	MN	JR	IO	SU	MO	MP	LN	IM	KM	MM	LQ	IP
43274	II	JM	KR	KK	JR	OQ	MP	MM	LL	MM	FL	LQ	IP
43275	IJ	MO	PS	MM	JR	OQ	PP	NO	MM	MO	FF	QR	II
43276	HI	JM	JO	IN	JL	MQ	LP	MN	IM	KM	FL	LN	II
43277	LO	JN	RS	KM	LL	IP	MP	LL	LL	KM	FF	LQ	IP
43278	JL	JN	FP	KM	JR	QQ	MP	LM	LL	MM	FM	NQ	IM
43279	IJ	MM	KP	IM	RR	OO	MP	NN	IM	MO	MM	QQ	IP
43280	II	MN	SS	II	LU	MM	LP	MN	LM	MM	MM	LL	IP
43281	HJ	MN	PR	II	JS	OP	PP	LM	KL	LP	FJ	KQ	NP

Appendix M. PopEquus Population Modeling Results

PopEquus (1.0.1) Advanced Tool - Simulation Report
28 March 2024 09:50:41 (Alternatives 1, Proposed Action)

Population inputs

You used the *PopEquus* Advanced Tool to simulate a horse population that started with 752 horses, had a population sex ratio where 0.5 of the population is female, was censused at a time that foals were present (No), had a mean annual population growth rate of 15% per year, and a capture probability during management (e.g., helicopter gather) of 0.8. You assumed that the target population size range for the population (i.e., Appropriate Management Level) was 134-195 horses, that removals aimed for a target population size of 134, and that if the population decreased to beneath 30 horses that it would be at high risk of local extirpation. In summary:

- Population size: 752
- Female proportion of population: 0.5
- Foals included in population size? No
- Population growth rate (% increase per year): 15
- Capture proportion during gathers: 0.8
- Appropriate management level (minimum): 134
- Appropriate management level (maximum): 195
- Target population size: 134
- Persistence threshold (i.e., minimum number of individuals): 30

Simulation inputs

You simulated populations over a 10-year projection interval, and you performed 20 replicate projections.

- Projection interval (years): 10
- Number of simulation replicates: 20

Management alternatives

You simulated 3 management alternatives using the tool: **Removals and GonaCon, Removals and PZP-22, Removals and ZonaStat-H**.

The following settings were specified for management actions:

Gather options

- Short-term holding costs ($ per day): 7.61

Removal options

- Removal years: 1, 4, 7, 10
- Reactive removals: No
- Minimum gather interval (years) for a reactive removal: 2
- Selective removals: Yes
- Male proportion of population returned after a removal: 0.6

- Maximum number removed from the population per year: 1500
- Number of years to project holding population: 25
- Long-term holding costs ($ per day): 2.02
- Proportion of horses adopted per year: 0.69
- Net adoption cost to agency ($ per horse): 1775
- Breeding reduction (%) of removed females in captivity the first year after removal: 25

GonaCon options

- Treatment years: 1, 4, 7, 10
- Treatment ages: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
- Treatment percentage (%) for age-eligible females: 100
- Treatment cost per shot ($): 50
- Hold to give booster treatment: Yes
- Days in holding until booster: 30

PZP-22 options

- Treatment years: 1, 4, 7, 10
- Treatment ages: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
- Treatment percentage (%) for age-eligible females: 100
- Primer treatment cost ($): 430
- Days in holding to receive treatment: 7
- Booster treatment cost ($): 30

ZonaStat-H options

- Treatment years: 1, 4, 7, 10
- Treatment ages: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
- Treatment percentage (%) for age-eligible females: 100
- Primer treatment cost ($): 30
- Hold to give booster treatment: Yes
- Days in holding until booster: 30

Results

Simulation outcomes can be summarized with a table(s) describing mean values among replicates for relevant metrics. Metrics include: population size in the final year of the projection interval (‘Final population size’), average population size across all years (‘Mean population size’), proportion of replicates that ended within the AML (i.e., the likelihood that an alternative yielded AML in the final year; ‘AML probability’), proportion of replicates that ended above the persistence threshold (‘Persistence probability’), total number of horses gathered (‘Number gathered’), total number of horses removed (‘Number removed’), total number of horses treated (‘Number treated’), cost of management in the Herd Management Area (HMA) in millions of USD [‘On-range cost ($ million)’], and total cost of management, including costs incurred at the HMA and in holding facilities [‘Total cost ($ million)’]. Values in parentheses are 95% confidence intervals.

Table M-1. The estimated effect of a range of alternatives on population size on the three HMAs.

Alternative	Final population size	Overall mean population size	AML probability
Removals and GonaCon	175 (127-205)	229 (218-240)	0.70
Removals and PZP-22	166 (152-212)	241 (229-252)	0.90
Removals and ZonaStat-H	181 (156-221)	240 (228-255)	0.80

Table M-2. The estimated number of wild horses gathered, removed, and treated per a range of alternatives for the three HMAs.

Alternative	Persistence probability	Number gathered	Number removed	Number treated
Removals and GonaCon	1.00	1074 (1040-1102)	720 (675-765)	154 (131-197)
Removals and PZP-22	1.00	1129 (1093-1173)	805 (753-853)	141 (106-182)
Removals and ZonaStat-H	1.00	1124 (1080–1178)	800 (751-852)	139 (106-176)

Table M-3. The estimated number on-range cost, off-range cost, and total cost ($ million) for a range of alternatives for the three HMAs.

Alternative	On-range cost ($ million)	Off-range cost ($ million)	Total cost ($ million)
Removals and GonaCon	0.94 (0.91-0.97)	5.53 (5.14-5.80)	6.47 (6.08-6.75)
Removals and PZP-22	0.99 (0.96-1.03)	6.07 (5.71-6.47)	7.06 (6.68-7.47)
Removals and ZonaStat-H	0.97 (0.94-1.01)	5.99 (5.59-6.41)	6.96 (6.54-7.42)

A graph of population size through time can be used to visualize effects of management alternatives on population size. Different colored lines indicate management alternatives simulated by the user; for each alternative, individual lines are different simulation replicates, that vary due to random chance. Dashed horizontal black lines indicate the minimum and maximum target population size range (i.e., AML).

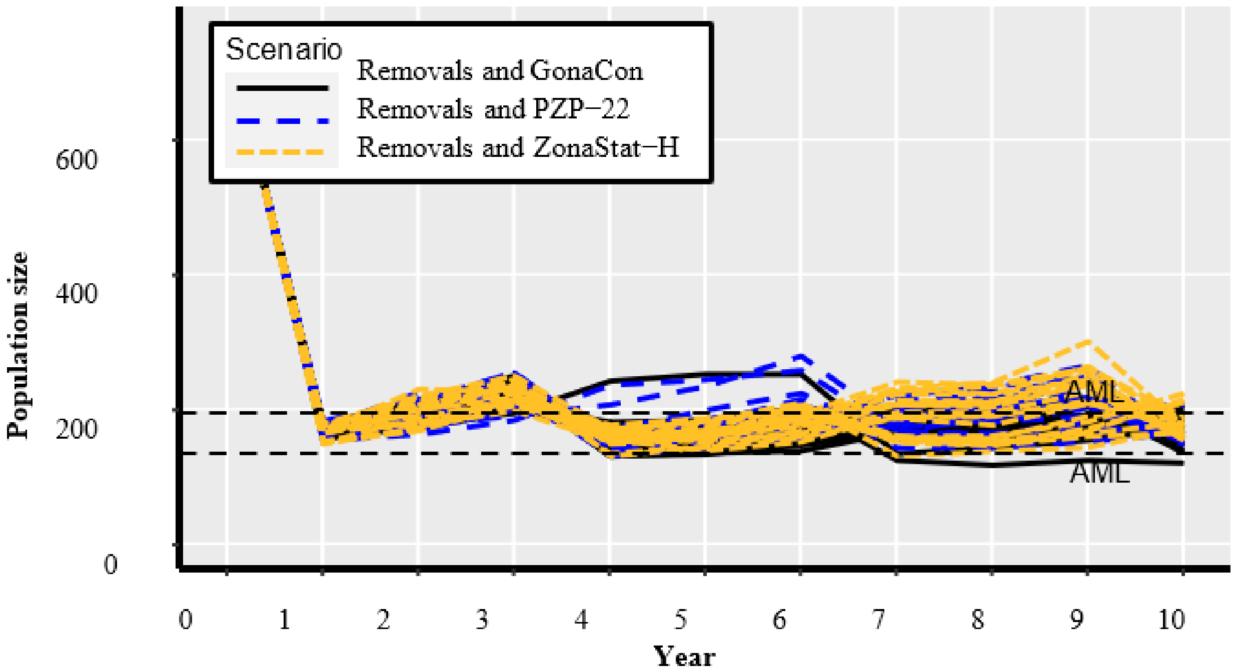

Figure M-1. The effects of three different management methods on the combined population size of the three HMAs.

Individuals might be interested in identifying a management alternative(s) that achieves the reduction or maintenance of a population within the target population size range (i.e., AML) while also incurring lower direct costs relative to other options. We can visualize the relationship between predicted population size and direct costs of management by graphing the overall mean population size (number of horses) on the x-axis and total cost of management (millions of USD) on the y-axis predicted by each alternative. Points are mean predictions among replicates and are colored by scenario (as in in the first graph); horizontal and vertical lines from points represent 95% confidence intervals in predicted population size and cost, respectively, for each scenario. While this graph does not account for all factors that might be important during management decisions, the graph provides a useful illustration of the trade-off between predicted population size and total direct cost of management resulting from the simulated alternatives.

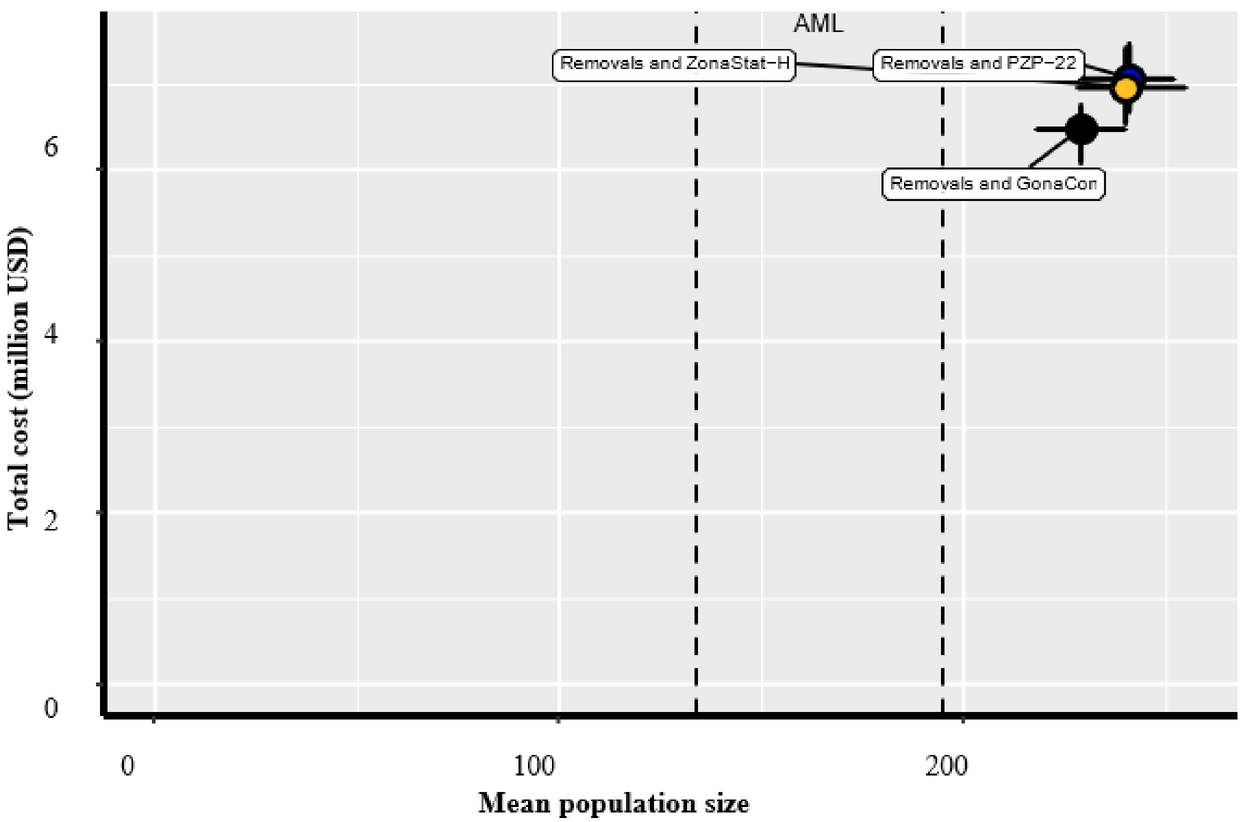

Figure M-2. Direct costs management based on the combined population size of the three HMAs.

Summary

The alternative that yielded the smallest average population size was:

```
## [1] "Removals and GonaCon"
```

The alternative that incurred the lowest direct costs ‘on range’ (other than ‘no management’) over the next 10 years was:

```
## [1] "Removals and GonaCon"
```

The alternative that incurred the lowest total direct costs across the sum of ‘on range’ and ‘off range’ (other than ‘no management’) over the next 35 years was:

```
## [1] "Removals and GonaCon"
```

Among the alternatives that achieved population size within Appropriate Management Levels, the alternative that incurred the lowest total direct costs across the sum of ‘on range’ and ‘off range’:

```
## [1] "None"
```

Note: results from the simulations may not be the sole basis for a management decision. The model does not explicitly account for or consider multiple uses on public lands, local land use planning considerations, ecological costs of horses on ecosystems, or other important values. The results presented here reflect considerations related to population size, amount of management, and fiscal costs of management that were estimated, given the input parameters and alternatives specified.

PopEquus (1.0.1) Advanced Tool - Simulation Report 28 March 2024 09:47:08 (Alternatives 2,3,4)

Population inputs

You used the *PopEquus* Advanced Tool to simulate a horse population that started with 752 horses, had a population sex ratio where 0.5 of the population is female, was censused at a time that foals were present (No), had a mean annual population growth rate of 15% per year, and a capture probability during management (e.g., helicopter gather) of 0.8. You assumed that the target population size range for the population (i.e., Appropriate Management Level) was 134-195 horses, that removals aimed for a target population size of 134, and that if the population decreased to beneath 30 horses that it would be at high risk of local extirpation. In summary:

- Population size: 752
- Female proportion of population: 0.5
- Foals included in population size? No
- Population growth rate (% increase per year): 15
- Capture proportion during gathers: 0.8
- Appropriate management level (minimum): 134
- Appropriate management level (maximum): 195
- Target population size: 134
- Persistence threshold (i.e., minimum number of individuals): 30

Simulation inputs

You simulated populations over a 10-year projection interval, and you performed 20 replicate projections.

- Projection interval (years): 10
- Number of simulation replicates: 20

Management alternatives

You simulated 5 management alternatives using the tool: **No management, Removals, Removals and GonaCon, Removals and PZP-22, Removals and ZonaStat-H**.

The following settings were specified for management actions:

Gather options

- Short-term holding costs ($ per day): 7.61

Removal options

- Removal years: 1, 4, 7, 10
- Reactive removals: No
- Minimum gather interval (years) for a reactive removal: 2
- Selective removals: Yes
- Male proportion of population returned after a removal: 0.5
- Maximum number removed from the population per year: 1500
- Number of years to project holding population: 25

- Long-term holding costs ($ per day): 2.02
- Proportion of horses adopted per year: 0.69
- Net adoption cost to agency ($ per horse): 1775
- Breeding reduction (%) of removed females in captivity the first year after removal: 25

GonaCon options

- Treatment years: 1, 4, 7, 10
- Treatment ages: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
- Treatment percentage (%) for age-eligible females: 100
- Treatment cost per shot ($): 50
- Hold to give booster treatment: Yes
- Days in holding until booster: 30

PZP-22 options

- Treatment years: 1, 4, 7, 10
- Treatment ages: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
- Treatment percentage (%) for age-eligible females: 100
- Primer treatment cost ($): 430
- Days in holding to receive treatment: 7
- Booster treatment cost ($): 30

ZonaStat-H options

- Treatment years: 1, 4, 7, 10
- Treatment ages: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
- Treatment percentage (%) for age-eligible females: 100
- Primer treatment cost ($): 30
- Hold to give booster treatment: Yes
- Days in holding until booster: 30

Results

Simulation outcomes can be summarized with a table(s) describing mean values among replicates for relevant metrics. Metrics include: population size in the final year of the projection interval ('Final population size'), average population size across all years ('Mean population size'), proportion of replicates that ended within the AML (i.e., the likelihood that an alternative yielded AML in the final year; 'AML probability'), proportion of replicates that ended above the persistence threshold ('Persistence probability'), total number of horses gathered ('Number gathered'), total number of horses removed ('Number removed'), total number of horses treated ('Number treated'), cost of management in the Herd Management Area (HMA) in millions of USD ['On-range cost ($ million)'], and total cost of management, including costs incurred at the HMA and in holding facilities ['Total cost ($ million)']. Values in parentheses are 95% confidence intervals.

Table M-4. The estimated effect of a range of alternatives on the population size of the three HMAs.

Alternative	Final population size	Overall mean population size	AML probability
No management	3015 (2438-3557)	1654 (1440-1868)	0.00
Removals	163 (137-207)	243 (232-259)	0.95
Removals and GonaCon	169 (121-209)	230 (219-239)	0.75
Removals and PZP-22	174 (146-223)	242 (234-257)	0.75
Removals and ZonaStat-H	173 (148-228)	242 (228-256)	0.85

Table M-5. The estimated number of wild horses gathered, removed, and treated per a range of alternatives for the three HMAs.

Alternative	Persistence probability	Number gathered	Number removed	Number treated
No management	1.00	0 (0-0)	0 (0-0)	0 (0-0)
Removals	1.00	1091 (962-1181)	861 (779-915)	0 (0-0)
Removals and GonaCon	1.00	1082 (1047-1116)	728 (680-782)	176 (158-203)
Removals and PZP-22	1.00	1134 (1096-1194)	808 (753-883)	166 (146-188)
Removals and ZonaStat-H	1.00	1140 (1082-1183)	813 (757-877)	161 (129-193)

Table M-6. The estimated number on-range cost, off-range cost, and total cost ($ million) for a range of alternatives for the three HMAs.

Alternative	On-range cost ($ million)	Off-range cost ($ million)	Total cost ($ million)
No management	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)
Removals	0.91 (0.79-0.99)	6.37 (5.77-6.80)	7.28 (6.59-7.74)
Removals and GonaCon	0.95 (0.92-0.97)	5.54 (5.18-6.04)	6.49 (6.13-7.00)
Removals and PZP-22	1.00 (0.97-1.05)	6.04 (5.49-6.58)	7.04 (6.48-7.63)
Removals and ZonaStat-H	0.99 (0.94-1.02)	6.02 (5.37-6.51)	7.01 (6.31-7.50)

A graph of population size through time can be used to visualize effects of management alternatives on population size. Different colored lines indicate management alternatives simulated by the user; for each alternative, individual lines are different simulation replicates, that vary due to random chance. Dashed horizontal black lines indicate the minimum and maximum target population size range (i.e., AML).

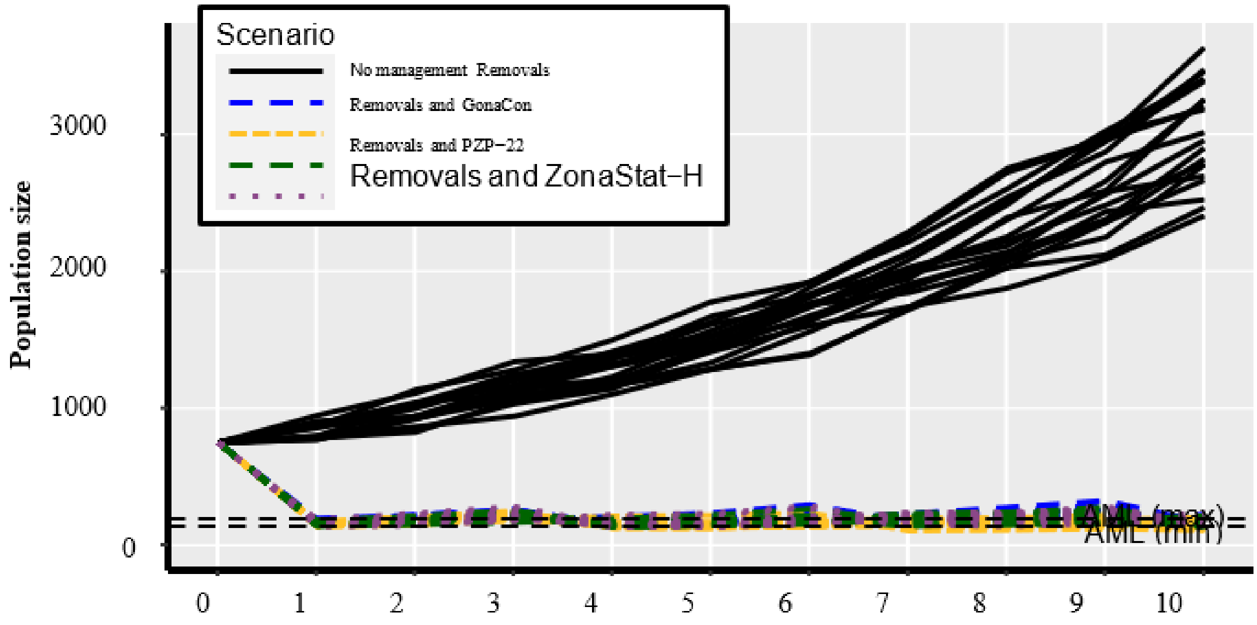

Figure M-3. Effects of various management methods on the estimated combined population size over the next 10-years for the three HMAs.

Individuals might be interested in identifying a management alternative(s) that achieves the reduction or maintenance of a population within the target population size range (i.e., AML) while also incurring lower direct costs relative to other options. We can visualize the relationship between predicted population size and direct costs of management by graphing the overall mean population size (number of horses) on the x-axis and total cost of management (millions of USD) on the y-axis predicted by each alternative. Points are mean predictions among replicates and are colored by scenario (as in in the first graph); horizontal and vertical lines from points represent 95% confidence intervals in predicted population size and cost, respectively, for each scenario. While this graph does not account for all factors that might be important during management decisions, the graph provides a useful illustration of the trade-off between predicted population size and total direct cost of management resulting from the simulated alternatives.

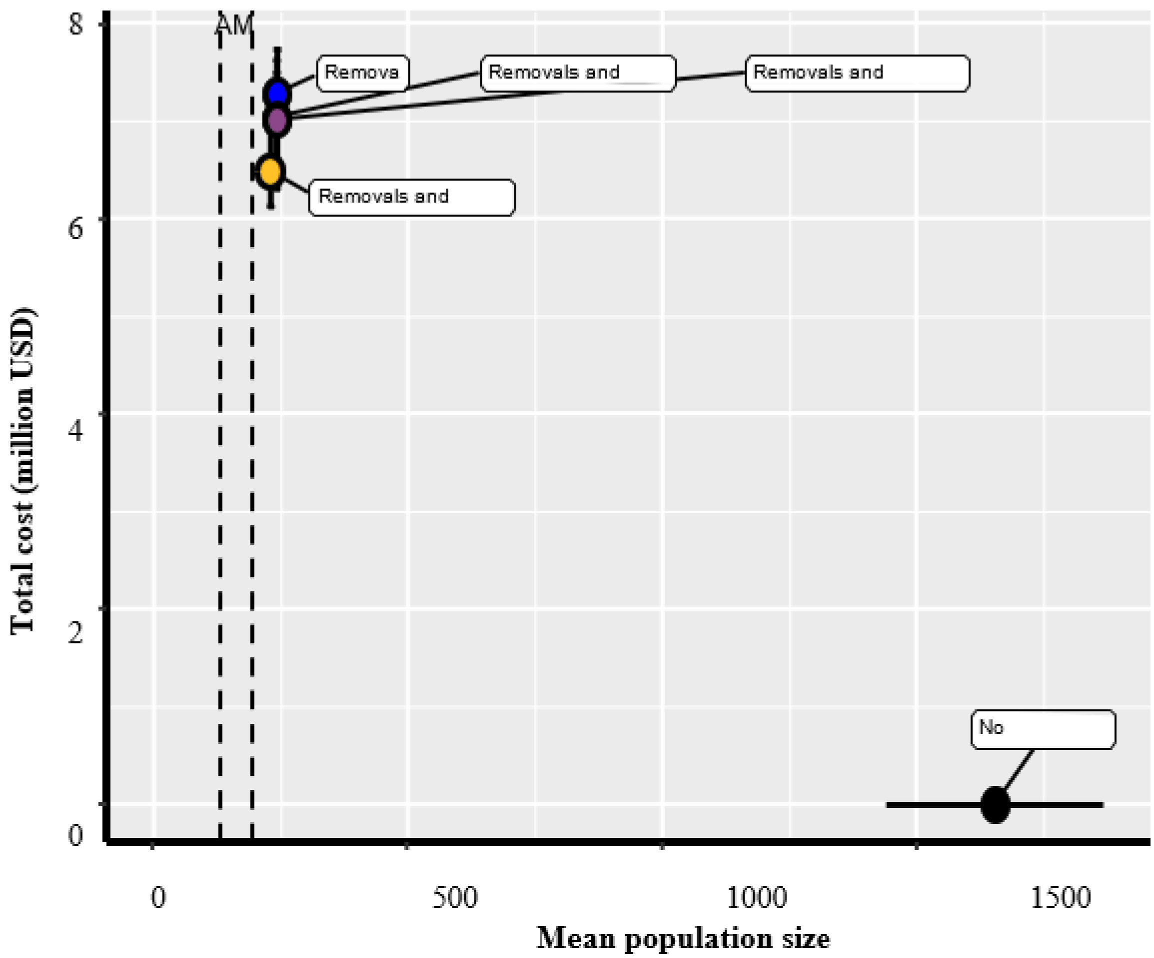

Figure M-4. The relationship between the total direct cost (in millions) to various management methods.

Summary

The alternative that yielded the smallest average population size was:

```
## [1] "Removals and GonaCon"
```

The alternative that incurred the lowest direct costs 'on range' (other than 'no management') over the next 10 years was:

```
## [1] "Removals"
```

The alternative that incurred the lowest total direct costs across the sum of 'on range' and 'off range' (other than 'no management') over the next 35 years was:

```
## [1] "Removals and GonaCon"
```

Among the alternatives that achieved population size within Appropriate Management Levels, the alternative that incurred the lowest total direct costs across the sum of 'on range' and 'off range':

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## [1] "None"
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Note: results from the simulations may not be the sole basis for a management decision. The model does not explicitly account for or consider multiple uses on public lands, local land use planning considerations, ecological costs of horses on ecosystems, or other important values. The results presented here reflect considerations related to population size, amount of management, and fiscal costs of management that were estimated, given the input parameters and alternatives specified.

Appendix N. Literature Reviews

This appendix includes scientific literature reviews addressing six topics: effects of gathers, effects of wild horses and burros on rangeland ecosystems, effects of fertility control vaccines and sex ratio manipulations, effects of sterilization, effects of intrauterine devices (IUDs), and effects of radio collars and radio tail tags. Even though physical sterilization methods are not a part of any alternative considered in the EA, the review about those methods is included in this appendix for the sake of contrasting the effects of those methods with effects of vaccine-based, IUD-based, and sex ratio manipulation-based population growth suppression.

Effects of Gathers on Wild Horses and Burros

Gathering any wild animals into pens has the potential to cause impacts to individual animals. There is also the potential for impacts to individual horses and burros during transportation, short-term holding, long-term holding that take place after a gather. However, BLM follows guidelines to minimize those impacts and ensure humane animal care and high standards of welfare. The following literature review summarizes the limited number of scientific papers and government reports that have examined the effects of gathers and holding on wild horses and burros.

Two early papers, by Hansen and Mosley (2000) and Ashley and Holcomb (2001) examined limited effects of gathers, including behavioral effects and effects on foaling rates. Hansen and Mosley (2000) observed BLM gathers in Idaho and Wyoming. They monitored wild horse behaviors before and after a gather event, and compared the behavioral and reproductive outcomes for animals that were gathered by helicopter against those outcomes for animals that were not. This comparison led to the conclusion that gather activities used at that time had no effect on observed wild horse foraging or social behaviors, in terms of time spent resting, feeding, vigilant, traveling, or engaged in agonistic encounters (Hansen & Mosley, 2000). Similarly, the authors did not find any statistically significant difference in foaling rates in the year after the gather in comparisons between horses that were captured, those that were chased by a helicopter but evaded capture, or those that were not chased by a helicopter. The authors concluded that the gathers had no deleterious effects on behavior or reproduction. Ashley and Holcomb (2001) conducted observations of reproductive rates at Garfield Flat HMA in Nevada, where horses were gathered in 1993 and 1997, and compared those observations at Granite Range HMA in Nevada, where there was no gather. The authors found that the two gathers had a short-term effect on foaling rates; pregnant mares that were gathered had lower foaling rates than pregnant mares that were not gathered. The authors suggested that BLM make changes to the gather methods used at that time, to minimize the length of time that pregnant mares are held prior to their release back to the range. Since the publications by Hansen and Mosley (2000) and by Ashley and Holcomb (2001), BLM did make changes to reduce the stress that gathered animals, including pregnant females, may experience as a result of gather and removal activities; these measures have been formalized as policy in the comprehensive animal welfare program (PIM 2021-002; BLM, 2021). That policy also covers care of animals in corrals, where measures to ensure wild horse and burro health and welfare include oversight by attending veterinarians.

A thorough review of gather practices and their effects on wild horses and burros can be found in a 2008 report from the Government Accounting Office. The report found that the BLM had controls in place to help ensure the humane treatment of wild horses and burros (GAO, 2008). The controls included SOPs for gather operations, inspections, and data collection to monitor animal welfare. These procedures led to humane treatment during gathers, and in short-term and long-term holding facilities. The report found that cumulative effects associated with the capture and removal of excess wild horses include gather-related mortality averaged only about 0.5% and approximately 0.7% of the captured animals, on average, are humanely euthanized due to pre-existing conditions (such as lameness or club feet) in accordance with BLM policy. Scasta (2020) found the same overall mortality rate (1.2%) for BLM WH&B gathers in 2010-2019, with a mortality rate of 0.25% caused directly by the gather, and a mortality rate of 0.94% attributable to euthanasia of animals with pre-existing conditions such as blindness or club-footedness. Scasta (2020) summarized mortality rates from 70 BLM WH&B gathers across nine states, from 2010-2019. Records for 28,821 horses and 2,005 burros came from helicopter and bait/water trapping. For wild burro bait / water trapping, mortality rates were 0.05% due to acute injury caused by the gather process, and death for burros with pre-existing conditions was 0.2% (Scasta, 2020). For wild horse bait / water trapping, mortality rates were 0.3% due to acute injury, and the mortality rate due to pre-existing conditions was 1.4% (Scasta, 2020). For wild horses gathered with the help of helicopters, mortality rates were only slightly lower than for bait / water trapping, with 0.3% due to acute causes, and 0.8% due to pre-existing conditions (Scasta, 2020). Scasta (2020) noted that for other wildlife species capture operations, mortality rates above 2% are considered unacceptable and that, by that measure, BLM WH&B "…welfare is being optimized to a level acceptable across other animal handling disciplines." In a separate analysis of 2010-2019 BLM wild horse gathers, Scasta et al. (2021) concluded that fewer than 20% of wild horse deaths at gathers were attributable to acute causes, with the great majority being euthanasia of animals with pre-existing, chronic conditions.

King et al. (2023) studied the fate of wild horse foals, as part of a broader 2016-2020 study on the effects of having some geldings in with breeding herds. In two HMAs in Utah that were intensively monitored for 4 years, about 5% of foals died in their first year of life, and about 2.5% of foals younger than 70 days old that became separated from their mothers (dams) survived and joined other social bands. BLM gather activities were not associated with any statistical increase in foal mortality, foal separation from their dams, or infanticide. King et al. (2023) concluded that, "…separation of offspring may be more common than previously considered, and that this is a natural event that does not necessarily result in mortality. … the separation of young foals from their dams was not a result of human disturbance or handling, resulting in the conclusion that foals even as young as 2 months old have a good chance of survival if separated from their dam or orphaned, as long as other social groups remain on the range that they can join."

The GAO report (2008) noted the precautions that BLM takes before gather operations, including screening potential gather sites for environmental and safety concerns, approving facility plans to ensure that there are no hazards to the animals there, and limiting the speeds that animals travel to trap sites. BLM used SOPs for short-term holding facilities (e.g., corrals) that included procedures to minimize excitement of the animals to prevent injury, separating horses by age, sex, and size, regular observation of the animals, and recording information about the animals in a BLM database. The GAO reported that BLM had regular inspections of short-term holding facilities and the animals that there, ensuring that the corral equipment is up to code and that animals are treated with appropriate veterinary care (including that hooves are trimmed adequately to prevent injury). Mortality was found to be about 5% per year associated with transportation, short-term holding, and adoption or sale with limitations. The GAO noted that BLM also had controls in place to ensure humane care at long-term holding facilities (i.e., pastures). BLM staff monitor the number of animals, the pasture conditions, winter feeding, and animal health. Veterinarians from the USDA Animal and Plant Health Inspection Service inspect long-term facilities annually, including a full count of animals, with written reports. Contract veterinarians provide animal care at long-term facilities, when needed. Weekly counts provide an incentive for contractors that operate long-term holding facilities to maintain animal health (GAO, 2008). Mortality at long-term holding was found to be about 8% per year, on average (GAO, 2008). The mortality rates at short-term and long-term holding facilities are comparable to the natural annual mortality rate on the range of about 16% per year for foals (animals under age 1), about 5-10% per year for horses ages 1-10 years, and about 10-25% for animals aged 10-20 years (Ransom et al., 2016).

In 2010, the American Association of Equine Practitioners (AAEP, 2011) was invited by the BLM to visit the BLM operations and facilities, spend time on WH&B gathers and evaluate the management of the wild equids. The AAEP Task Force evaluated horses in the BLM Wild Horse and Burro Program through several visits to wild horse gathers, and short- and long-term holding facilities. The task force was specifically asked to "review animal care and handling within the Wild Horse and Burro Program, and make whatever recommendations, if any, the Association feels may be indicated, and if possible, issue a public statement regarding the care and welfare of animals under BLM management." In their report (AAEP, 2011), the task force concluded "that the care, handling and management practices utilized by the agency are appropriate for this population of horses and generally support the safety, health status and welfare of the animals." The comprehensive animal welfare program (BLM, 2021) includes standards of care of animals in corrals, where measures include oversight by attending veterinarians.

In June 2010 BLM invited independent observers organized by American Horse Protection Association (AHPA) to observe BLM gathers and document their findings. AHPA engaged four independent credentialed professionals who are academia-based equine veterinarians or equine specialists. Each observer served on a team of two and was tasked specifically to observe the care and handling of the animals for a 3-4-day period during the gather process and submit their findings to AHPA. An Evaluation Checklist was provided to each of the observers that included four sections: Gather Activities; Horse Handling During Gather; Horse Description; and Temporary Holding Facility. The independent group visited 3 separate gather operations and found that "BLM and contractors are responsible and concerned about the welfare of the horses before, during and after the gather process" and that "gentle and knowledgeable, used acceptable methods for moving horses… demonstrated the ability to review, assess and adapt procedures to ensure the care and well-being of the animals" (Greene et al., 2013).

BLM commissioned the Natural Resources Council of the National Research Council of the National Academies of Sciences to conduct an independent, technical evaluation of the science, methodology, and technical decision-making approaches of the BLM Wild Horse and Burro Management Program. Among the conclusions of their 2013 report, NRC (2013) concluded that wild horse populations grow at 15-20% a year, and that predation would not typically control population growth rates of free-ranging horses. The report (NRC, 2013) also noted that, because there are human-created barriers to dispersal and movement, such as fences and highways, and not enough substantial predator pressure to actually cause herds to decrease, maintaining a herd within an AML requires removing animals in roundups, also known as gathers, and may require management actions that limit population growth rates. The report (NRC, 2013) examined a number of population growth suppression techniques, including the use of sterilization, fertility control vaccines, and sex ratio manipulation.

The effects of gathers as part of feral horse management have also been documented on National Park Service Lands. Since the 1980s, managers at Theodore Roosevelt National Park have used periodic gathers, removals, and auctions to maintain the feral horse herd size at a carrying capacity level of 50 to 90 horses (Amberg et al., 2014). In practical terms, this carrying capacity is equivalent to an AML. Horse herd sizes at those levels were determined to allow for maintenance of certain sensitive forage plant species. Gathers every 3-5 years did not prevent the herd from self-sustaining. The herd continues to grow, to the point that the NPS now uses gathers and removals along with temporary fertility control methods in its feral horse management (Amberg et al., 2014).

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Effects of Wild Horses and Burros on Rangeland Ecosystems

The presence of wild horses and wild burros can have substantial effects on rangeland ecosystems, and on the capacity for habitat restoration efforts to achieve landscape conservation and restoration goals. While wild horses and burros may have some beneficial ecological effects, such benefits are outweighed by ecological damage they cause when herds are at levels greater than supportable by allocated, available natural resources (i.e., when herds are greater than AML).

In the biological sense, all free-roaming horses and burros in North America are feral, meaning that they are descendants of domesticated animals brought to the Americas by European colonists. Available evidence has indicated that horses went extinct in the Americas by the end of the Pleistocene, about 10,000 years ago (Webb, 1984; MacFadden, 2005), though DNA samples from permafrost suggest their extinction from Alaska could possibly have been as recent as about 6,000 years ago (Murchie et al., 2021). Burros evolved in Eurasia (Geigl et al., 2016). After domesticated horses were introduced to the Americas, their geographic distribution was facilitated by Native Americans and colonizing Europeans (Taylor et al., 2023a, 2023b). The published literature refers to free-roaming horses and burros as either feral or wild. In the ecological context the terms are interchangeable, but the terms 'wild horse' and 'wild burro' are associated with a specific legal status. The legal status of federally recognized wild horses and burros stems entirely from the WFRHBA of 1971 and is not dependent on whether the animals are or are not considered 'native' to the particular lands of the western USA where they are managed by the BLM and US Forest Service. Whether or not those animals were continuously present throughout the Holocene period in the 10 states where they are currently managed does not appear to influence the magnitude or direction of their ecological effects (Lundgren et al., 2024), but those effects are by no measure benign with respect to less well-known plant and animal species, many of which have far more limited geographic distributions.

The following literature review on the effects of wild horses and burros on rangeland ecosystems draws on scientific studies of feral horses and burros, some of which also have wild horse or wild burro legal status. Parts of this review draw heavily on Parts 1 and 2 of the 'Science framework for conservation and restoration of the sagebrush biome' interagency report (Chambers et al., 2017; Crist et al., 2019).

Because of the known damage that overpopulated wild horse and burro herds can cause in rangeland ecosystems, the presence of wild horses and burros is considered a threat to Greater sage-grouse habitat quality, particularly in the bird species' western range (Beever & Aldridge, 2011; USFWS, 2013). Wild horse population sizes on federal lands have more than doubled in the five years since the USFWS report (2013) was published (BLM, 2018). On lands administered by the BLM, there were over 82,000 BLM-administered wild horses and burros as of March 1, 2022, which does not include foals born in 2020. Lands with wild horses and burros are managed for multiple uses; scientific studies designed to separate out effects of wild horses and burros, which are summarized below, point to conclusions that landscapes with greater wild horse and burro abundance would tend to have lower resilience to disturbance and lower resistance to invasive plants than similar landscapes with herds at or below target AML levels.

In contrast to managed livestock grazing, neither the seasonal timing nor the intensity of wild horse and burro grazing can be managed, except through efforts to manage their numbers and distribution. Wild horses live on the range year-round, they roam freely, and wild horse populations have the potential to grow 15-20% per year (Wolfe, 1980; Eberhardt et al., 1982; Garrott et al., 1991; Dawson, 2005; Roelle et al., 2010; Scorolli et al., 2010). Although this annual growth rate may be lower in some areas where mountain lions can take foals (Turner & Morrison, 2001; Turner, 2015), horses tend to favor use of more open habitats (Schoenecker, 2016) that are dominated by grasses and shrubs and where ambush is less likely. Wild horses may compete for forage with elk, mule deer, other wild ungulates, and managed livestock (Smith et al., 1986a; Scasta et al., 2016; Platte & Torland, 2024).

As a result of the potential for wild horse populations to grow rapidly, impacts from wild horses on water, soil, vegetation, and native wildlife resources (Davies & Boyd, 2019) can increase exponentially unless there is active management to limit their population sizes. For the majority of wild horse herds, there is little overall evidence that population growth is significantly affected by predation (NRC, 2013), although wild horse and burro herd growth rates may be somewhat reduced by predation in some localized areas, particularly where individual cougars specialize on horse or burro predation (Turner & Morrison, 2001; Roelle et al., 2010; Mesler & Jones, 2021). Andreasen et al. (2021) and Iacono (2023) found that the level of specializing on young horse varies across individual mountain lions (*Puma concolor*). This specialization seems more prevalent where horses are at very high densities and native ungulates are at very low densities (Andreasen et al., 2021). The greatest rate of predation on horses, by mountain lions, was in the Virginia Range, where the state of Nevada manages a herd of feral horses that is not federally protected. Where lion predation on horses was common, Andreasen et al. (2021) found that female lions preyed on horses year-round, but 13% or fewer of horses killed by lions were adults. Andreasen et al. (2021) concluded that, “at landscape scales, cougar predation is unlikely to limit the growth of feral horse populations.” Mesler and Jones (2021) also documented that some mountain lions have a far higher prevalence of wild burro in their diet than others, though their sample size was relatively lower than Andreasen et al. (2021) or Iacono (2023). Similarly, Lundgren et al. (2022) documented that mountain lions kill feral burros in Death Valley National Park. Lundgren et al. (2022) advocated for not eliminating wild equids from landscapes, but that is not a consideration on HMAs, where the BLM aims to have herd sizes of wild horses and burros that are at or above the low level of AML. BLM does not have the legal authority to regulate or manage mountain lion populations, and it is not clear whether there are any mountain lions in the Carter Reservoir, Coppersmith, or Buckhorn HMAs that specialize on horse predation. Andreasen et al. (2021) concluded that “At landscape scales, cougar predation is unlikely to limit the growth of feral horse populations.” In a study of Mexican wolf predation in an area of Arizona with free-roaming horses, horses were not part of the documented wolf diet (Smith et al., 2023). Given the recent history of consistent growth in the Carter Reservoir, Coppersmith, or Buckhorn HMA wild horse herds, as documented by repeated aerial survey (see EA section 1.2), the inference that predation does not limit local wild horse herd growth rates apparently applies.

The USFWS (2008), Beever and Aldridge (2011), and Chambers et al (2017) summarize much of the literature that quantifies direct ecosystem effects of wild horse presence. Beever and Aldridge (2011) present a conceptual model that illustrates the effects of wild horses on sagebrush ecosystems. In the Great Basin, areas without wild horses had greater shrub cover, plant cover, species richness, native plant cover, and overall plant biomass, and less cover percentage of grazing-tolerant, unpalatable, and invasive plant species, including cheatgrass, compared to areas with horses (Smith, 1986b; Beever et al., 2008; Davies et al., 2014; Zeigenfuss et al., 2014; Boyd et al., 2017). There were also measurable increases in soil penetration resistance and erosion, decreases in ant mound and granivorous small mammal densities, and changes in reptile communities (Beever et al., 2003; Beever & Brussard, 2004; Beever & Herrick, 2006; Ostermann-Kelm et al., 2009). Intensive grazing by horses and other ungulates can damage biological crusts (Belnap et al., 2001). In contrast to domestic livestock grazing, where post-fire grazing rest and deferment can foster recovery, wild horse grazing occurs year-round. These effects imply that horse presence can have broad effects on ecosystem function that could influence conservation and restoration actions.

Many studies corroborate the general conclusion that wild horses can lead to biologically significant changes in rangeland ecosystems, particularly when their populations are overabundant relative to water and forage resources, and other wildlife living on the landscape (Eldridge et al., 2020). The presence of wild horses is associated with a reduced degree of greater sage-grouse lekking behavior (Muñoz et al., 2020). Moreover, increasing densities of wild horses, measured as a percentage above AML, are associated with decreasing greater sage-grouse population sizes, measured by lek counts (Coates et al., 2021). Horses are primarily grazers (Hanley & Hanley, 1982), but shrubs – including sagebrush – can represent a large part of a horse's diet, at least in summer in the Great Basin (Nordquist, 2011). Horses may crop grazed plants closer to the ground than bovids because horses have agile lips and top and bottom teeth (McNew et al., 2023). Free-ranging equids have a high affinity for habitats that are close to water (Esmaeili et al., 2021; Karish et al., 2023), which appears to be stronger than for like-sized ruminants (Esmaeili et al., 2021). Grazing by wild horses can have severe impacts on water source quality, aquatic ecosystems and riparian communities as well (Beever & Brussard, 2000; Barnett, 2002; Nordquist, 2011; USFWS, 2008; Earnst et al., 2012; USFWS, 2012; Kaweck et al., 2018), sometimes excluding native ungulates from water sources (Ostermann-Kelm et al., 2008; USFWS, 2008; Perry et al., 2015; Hall et al., 2016; Gooch et al., 2017; Hall et al., 2018). Impacts to riparian vegetation per individual wild horse can exceed impacts per individual domestic cow (Kaweck et al., 2018; Burdick et al., 2021). Bird nest survival may be lower in areas with wild horses (Zalba & Cozzani, 2004), and bird populations have recovered substantially after livestock and / or wild horses have been removed (Earnst et al., 2005; Earnst et al., 2012; Batchelor et al., 2015). Wild horses can spread nonnative plant species, including cheatgrass, and may limit the effectiveness of habitat restoration projects (Beever et al., 2003; Couvreur et al., 2004; Jessop & Anderson, 2007; Loydi & Zalba, 2009). Riparian and wildlife habitat improvement projects intended to increase the availability of grasses, forbs, riparian habitats, and water would likely attract and be subject to heavy grazing and trampling by wild horses that live in the vicinity of the project. Even after domestic livestock are removed, continued wild horse grazing can cause ongoing detrimental ecosystem effects (USFWS, 2008; Davies et al., 2014) which may require several decades for recovery (Anderson & Inouye, 2001).

Wild horses and burros may have ecologically beneficial effects, especially when herd sizes are low relative to available natural resources, but those ecological benefits do not typically outweigh damage caused when herd sizes are high, relative to available natural resources. Under some conditions, there may not be observable competition with other ungulate species for water (Meeker, 1979), but recent studies that used remote cameras have found wild horses excluding native wildlife from water sources under conditions of relative water scarcity (Perry et al., 2015; Hall et al., 2016; Hall et al., 2018). Compared to landscapes where large herbivores such as horses and burros are completely absent, the presence of some large herbivores can cause local-scale ecological disturbances that may increase local species diversity (Trepel et al., 2024); this is consistent with the intermediate disturbance hypothesis (Wilkinson, 1999), which also predicts that excessive disturbance leads to reduced species diversity. Wild burros (and, less frequently, wild horses) have been observed digging 'wells;' such digging may improve habitat conditions for some vertebrate species and, in one site, may improve tree seedling survival (Lundgren et al., 2021). This behavior has been observed in intermittent stream beds where subsurface water is within 2 meters of the surface (Lundgren et al., 2021). The BLM is not aware of published studies that document wild horses or burros in the western United States causing similar or widespread habitat amelioration on drier upland habitats such as sagebrush, grasslands, or pinyon-juniper woodlands. Lundgren et al. (2021) suggested that, due to well-digging in ephemeral streambeds, wild burros (and horses) could be considered 'ecosystem engineers;' a term for species that modify resource availability for other species (Jones et al., 1994). Rubin et al. (2021) and Bleich et al. (2021) responded by pointing out that ecological benefits from wild horse and burro presence must be weighed against ecological damage they can cause, especially at high densities. Burro density appears to be negatively correlated with endangered desert tortoise presence which implies that burros should be considered along with other known environmental factors that can degrade tortoise habitat and demographic rates (Berry et al., 2020).

In HMAs where wild horse and burro biomass is very large relative to the biomass of native ungulates (Boyce & McLoughlin, 2021), they should probably also be considered 'dominant species' (Power & Mills, 1995) whose ecological influences result from their prevalence on the landscape. Wild horse densities could be maintained at high levels in part because artificial selection for early or extended reproduction may mean that wild horse population dynamics are not constrained in the same way as large herbivores that were never domesticated (Boyce & McLoughlin, 2021). Another potentially positive ecological effect of wild horses and burros is that they, like all large herbivores, redistribute organic matter and nutrients in dung piles (King & Gurnell, 2006), which could disperse and improve germination of undigested seeds. This could be beneficial if the animals spread viable native plant seeds (Downer, 2022), but could have negative consequences if the animals spread viable seeds of invasive plants such as cheatgrass (Loydi & Zalba, 2009; King et al., 2019). Increased wild horse and burro density would be expected to increase the spatial extent and frequency of seed dispersal, whether the seeds distributed are desirable or undesirable.

As is true of herbivory by any grazing animals, light grazing can increase rates of nutrient cycling (Manley et al., 1995) and foster compensatory growth in grazed plants which may stimulate root growth (Osterheld & McNaughton, 1991; Schuman et al., 1999) and, potentially, an increase in carbon sequestration in the soil (Derner & Schuman, 2007; He et al., 2011). In Spain, Segarra et al. (2023) noted that an area lightly to moderately grazed by donkeys had lower net productivity but higher plant biodiversity than ungrazed pastures where trees were encroaching. However, when grazer density is high relative to available forage resources – as can be the case when wild horse and burro densities exceed AML – then overgrazing by any species can lead to long-term reductions in plant productivity, including decreased root biomass (Herbel, 1982; Williams et al., 1968) and potential reduction of stored carbon in soil horizons. Ecological processes associated with large herbivore carcass decomposition can contribute to higher insect and microbial diversity and localized nutrient flux to soils and plants, with effects that may last for several years (Newsome & Barton, 2023). Degraded ecosystems may not have the capacity to use and recycle the ecological benefits of decomposing carcasses to the same level as healthy, diverse, resilient ecosystems (Newsome & Barton, 2023).

Recognizing the potential beneficial effects of low-density wild horse and burro herds, but also recognizing the totality of available published studies documented ecological effects of wild horse and burro herds, especially when above AML (as noted elsewhere), it is prudent to conclude that horse and burro herd sizes above AML may cause levels of disturbance that reduce landscapes' capacity for resilience in the face of further disturbance, such as is posed by extreme weather events and other consequences of climate change.

Most analyses of wild horse effects have contrasted areas with wild horses to areas without, which is a study design that should control for effects of other grazers, but historical or ongoing effects of livestock grazing may be difficult to separate from horse effects in some cases (Davies et al., 2014). Analyses have generally not included horse density as a continuous covariate; therefore, ecosystem effects have not been quantified as a linear function of increasing wild horse density. One exception is an analysis of satellite imagery confirming that varied levels of feral horse biomass were negatively correlated with average plant biomass growth (Ziegenfuss et al., 2014).

Horses require access to large amounts of water; an individual can drink an average of 7.4 gallons of water per day (Groenendyk et al., 1988). Despite a general preference for habitats near water (Crane et al., 1997), wild horses routinely commute long distances (e.g., 10+ miles per day) between water sources and palatable vegetation (Hampson et al., 2010).

Wild burros can also substantially affect riparian habitats (Tiller, 1997), native wildlife (Seegmiller & Ohmart, 1981), and have grazing and trampling impacts that are similar to wild horses (Carothers et al., 1976; Hanley & Brady, 1977; Douglas & Hurst, 1993). Where wild burros and Greater sage-grouse co-occur, burros' year-round use of low-elevation habitats may lead to a high degree of overlap between burros and Greater sage-grouse (Beever & Aldridge, 2011).

References: Effects of Wild Horses and Burros on Rangeland Ecosystems

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Effects of Fertility Control Treatments and Sex Ratio Manipulations in Wild Horse and Burro Management

Various forms of fertility control can be used in wild horses and wild burros, with the goals of maintaining herds at or near AML, reducing fertility rates, and reducing the frequency of gathers and removals. The WFRHBA of 1971 specifically provides for contraception and sterilization (16 U.S.C. 1333 section 3.b.1). Although sex ratio manipulation is not expected to directly reduce individual fertility, it is included in discussions of fertility control treatments here because it can be a form of population growth suppression. Fertility control measures have been shown to be a cost-effective and humane treatment to slow increases in wild horse populations or, when used in combination with gathers, to reduce horse population size (Bartholow, 2004; de Seve & Boyles-Griffin, 2013; Fonner & Bohara, 2017). Although fertility control treatments may be associated with a number of potential physiological, behavioral, demographic, and genetic effects, those impacts are generally minor and transient, do not prevent overall maintenance of a self-sustaining population, and do not generally outweigh the potential benefits of using contraceptive treatments in situations where it is a management goal to reduce population growth rates (Garrott & Oli, 2013).

The percentage of effectively contracepted mares in the herd could vary over time, depending on the number of mares that are treated in different years, the formulation of vaccine that is used and the expected duration of vaccine effectiveness. After the initial gather, the BLM could use a population modeling software such as PopEquus (Folt et al., 2023a, 2023b) to help inform expectations about how many animals in future gathers or actions should be removed, or mares treated, in order to achieve herd management goals. Herd management projections and specific decisions about the number of mares to be treated in the future would be informed by the best available information at the time, based on the results of records of past treatments and on herd monitoring results. However, logistical constraints associated with gather scheduling (for vaccine hand-injection) and animal approachability (for dart-based vaccine treatments) are such that it is unlikely that the fraction of mares that are effectively contracepted in any given year would ever exceed 75%. Because of high foal and adult survival rates (Ransom et al., 2016), the likely result is that the herd would always have a positive growth rate over time.

An extensive body of peer-reviewed scientific literature details the impacts of fertility control methods on wild horses and burros. No finding of excess animals is required for BLM to pursue contraception in wild horses or wild burros, but NEPA analysis has been required, as there are possible effects to individuals and groups of wild horses and burros. This review focuses on peer-reviewed scientific literature. The summary that follows first examines effects of fertility control vaccine use in mares, then of sex ratio manipulation. This review does not examine effects of spaying and neutering and does not include an analysis of oocyte growth factor vaccine formulations. Cited studies are generally limited to those involving horses and burros, except where including studies on other species helps in making inferences about physiological or behavioral questions not yet addressed in horses or burros specifically. Burros (donkeys) are a distinct species from horses; however, they are both of the family Equidae. While there are notable differences between the species in their anatomy, diet, behaviors, and metabolism (Burden & Thiemann, 2015), the essential endocrine controls of the hypothalamic-pituitary-gonadal axis and the function of the zona pellucida in fertility are the same. While most studies reviewed are based on results from horses, burros are similar enough in their reproductive physiology and immunology (Turini et al., 2021) that expected effects of immunocontraception are comparable.

On the whole, the identified impacts of fertility control methods are generally transient – other than the contraceptive effects which are the purpose of treatment – and affect primarily the individuals treated. Fertility control that affects individual horses and burros does not prevent BLM from ensuring that there would be self-sustaining populations of wild horses and burros in single herd management areas (HMAs), in complexes of HMAs, and at regional scales of multiple HMAs and complexes. Under the WFRHBA of 1971, BLM is charged with maintaining self-reproducing populations of wild horses and burros. The National Research Council of the National Academies of Sciences (2013) encouraged BLM to manage wild horses and burros at the spatial scale of “metapopulations” – that is, across multiple HMAs and complexes in a region. In fact, many HMAs have historical and ongoing genetic and demographic connections with other HMAs, and BLM routinely moves animals from one to another to improve local herd traits and maintain high genetic diversity. The NRC report (2013) includes information (pairwise genetic 'fixation index' values for sampled WH&B herds) confirming that WH&B in the vast majority of HMAs are genetically similar to animals in multiple other HMAs.

All fertility control methods affect the behavior and physiology of treated animals (NRC, 2013), and are associated with potential risks and benefits, including effects of handling, frequency of handling, physiological effects, behavioral effects, and reduced population growth rates (Hampton et al., 2015). Contraception alone does not remove excess horses from an HMA's population, so one or more gathers are usually needed in order to bring the herd down to a level close to AML. Because population growth rates depend partly on the frequency of females that give birth (i.e., the foaling rate), the use of fertility control vaccination to reduce growth rates is more effective when a herd is relatively close to AML. Population modeling (Gross, 2000; deSeve & Boyles-Griffin, 2013; Folt et al., 2023a, 2023b) confirms the commonsense conclusion that the higher the fraction of contracepted mares, generally the lower the growth rate. Schulman et al. (2024) demonstrated that a shorter duration of effect requires larger fractions of mares need to be frequently treated to maintain a 'fertility control index' large enough to reduce herd-level growth rates. This is one reason that the BLM has historically sought to use humane, longer-lasting fertility control methods. For example, it is easier to achieve the 60-90% rate of effectively treated mares if the method used does not require treatment every year. Horses are long-lived, potentially reaching 20 years of age or more in the wild. Except in cases where extremely high fractions of mares are rendered infertile over long time periods of (i.e., 10 or more years), fertility control methods such as immunocontraceptive vaccines and sex ratio manipulation are not very effective at reducing population growth rates to the point where births equal deaths in a herd. However, even more modest fertility control activities can reduce the frequency of horse gather activities, and costs to taxpayers. Bartholow (2007) concluded that the application of 2-year or 3-year contraceptives to wild mares could reduce operational costs in a project area by 12-20%, or up to 30% in carefully planned population management programs.

In each of the three HMAs considered in this EA, population monitoring would be useful to guide BLM in achieving and maintaining the population at AML over the duration of the Proposed Action. To determine desired fertility control vaccine application rates in these herds, the BLM could use a population modeling software such as PopEquus (Folt et al., 2023a, 2023b) to help assess how many animals at that time should be removed or mares treated in order to achieve herd management goals and update its herd management projections in the future, based on the results of local, contemporaneous herd monitoring. Because applying contraception to horses often requires capturing and handling, the risks and costs associated with capture and handling of horses may be comparable to those of gathering for removal, but with expectedly lower adoption and long-term holding costs. Dart-based fertility control applications would entail no capture cost, but administration costs would vary in relation to approachability. Population growth suppression becomes less expensive if fertility control is long-lasting (Hobbs et al., 2000).

In the context of BLM wild horse and burro management, fertility control vaccines and sex ratio manipulation rely on reducing the number of reproducing females. Taking into consideration available literature on the subject, the National Research Council of the National Academies of Sciences concluded in their 2013 report that forms of fertility control vaccines were two of the three 'most promising' available methods for contraception in wild horses and burros (NRC, 2013). That report also noted that sex ratio manipulations where herds have approximately 60% males and 40% females can expect lower annual growth rates, simply as a result of having a lower number of reproducing females.

It is not realistic to rely on wild horse and burro herds to limit their own population size or growth rates in the western United States. Predators such as mountain lions tend to not fully prevent free-roaming horse population growth, even in locations where relatively high numbers of foals die per year, such as in the Virginia Range of Nevada (Schulman et al., 2024). Wild horses and burros are long-lived species with documented survival rates that can exceed 95% (Ransom et al., 2016) and they do not self-regulate their population (NRC, 2013). The National Research Council of the National Academies of Sciences report (NRC, 2013) concluded that the primary way that equid populations self-limit is through increased competition for forage at higher densities, which results in smaller quantities of forage available per animal, poorer body condition and decreased natality and survival. It also concluded that the effect of this would be impacts to resource and herd health that are contrary to BLM management objectives and statutory and regulatory mandates. In the absence of management actions to limit the herd size, wild horse and burro populations would be expected to increase to a point where forage and/ or water resources are depleted resulting in the irreversible loss of native vegetation, a loss of wildlife habitat (including riparian habitat), and eventually the potential for periodic large-scale die-offs of the wild horses and burros themselves (NRC, 2013). In a detailed demographic study of a growing population of Przewalski horses in Hungary, Kerekes et al. (2021) did observe slight reductions in foaling rates at high population sizes, but not nearly enough to prevent the population from continuing to grow at high annual rates, except during a winter die-off event when a quarter of the herd died. As such, there is a continuing need for active wild horse and burro herd management, such as through removals and fertility control.

Fertility Control Vaccines

Fertility control vaccines (also known as (immunocontraceptives) meet BLM requirements for safety to mares and the environment (EPA, 2009, 2012). Because they work by causing an immune response in treated animals, there is no risk of hormones or toxins being taken into the food chain when a treated mare dies. The BLM and other land managers have mainly used three fertility control vaccine formulations for fertility control of wild horse mares on the range: ZonaStat-H, PZP-22, and GonaCon-Equine. As other formulations become available, they may be applied in the future.

In any vaccine, the antigen is the stimulant to which the body responds by making antigen-specific antibodies. Those antibodies then signal to the body that a foreign molecule is present, initiating an immune response that removes the molecule or cell. Adjuvants are additional substances that are included in vaccines to elevate the level of immune response. Adjuvants help to incite recruitment of lymphocytes and other immune cells which foster a long-lasting immune response that is specific to the antigen.

Liquid emulsion vaccines can be injected by hand or remotely administered in the field using a pneumatic dart (Roelle & Ransom, 2009; Rutberg et al., 2017; McCann et al., 2017) in cases where mares are relatively approachable. Use of remotely delivered (dart-delivered) vaccine is generally limited to populations where individual animals can be accurately identified and repeatedly approached within 50 m (BLM, 2010). Booster doses can be safely administered by hand or by dart. Even with repeated booster treatments of the vaccines, it is expected that most mares would eventually return to fertility, though some individual mares treated repeatedly may remain infertile. Once the herd size in a project area is at AML and population growth seems to be stabilized, BLM can make adaptive determinations as to the required frequency of new and booster treatments.

BLM has guidelines for fertility control vaccine application, with respect to selection of herds (BLM IM 2009-090). Herds selected for fertility control vaccine use should have annual growth rates over 5%, have a herd size over 50 animals, and have a target rate of treatment of between 50% and 90% of female wild horses or burros. Treated mares should be identifiable via a visible freeze brand or individual color markings, so that their vaccination history can be known. Follow-up population surveys should be used to determine the realized annual growth rate in herds treated with fertility control vaccines.

The BLM's potential application of PZP ZonaStat-H vaccine booster doses 2 weeks or more after an initial dose, and GonaCon-Equine booster doses 30 or more days after an initial dose are consistent with use specifications on the product labels (EPA, 2012, 2013). Temporarily holding animals or use of dart-based delivery to provide a booster dose does not require further study for justification. The Environmental Protection Agency regulates the use of fertility control agents such as the PZP vaccine ZonaStat-H or the GnRH vaccine GonaCon-Equine, in wild horses and burros. These vaccines are registered with the EPA and are not experimental. The EPA-required product label associated with the registration for ZonaStat-H is cited in the EA as EPA (2012). That label states that "For maximum efficacy, ZonaStat-H is administered as an initial priming dose followed by a booster dose at least two weeks later." The EPA-required product label associated with the registration for GonaCon-Equine is cited in the EA as EPA (2013). That label states that "If longer contraceptive effect is desired, a second vaccination may be given 30 or more days after the first injection or during the following year with no known adverse health effects to the vaccinated animal."

The explicit intention of BLM's potential use of fertility control vaccines such as PZP ZonaStat-H or GonaCon-Equine, is to reduce the fertility rate of treated individual mares for one or more years and, therefore, to reduce the herd-level annual growth rates. This outcome would be consistent with the Purpose and Need identified in the EA, and consistent with authorities in the WFRHBA. The BLM acknowledges that there is a range of possible duration of contraceptive effects (noted below). It is even possible that some fertility control vaccine-treated mares may not reproduce again before they die. The 2013 EPA label for GonaCon-Equine states that, "there is a chance some vaccinated females would become permanently sterile." Precise probabilistic estimates of the return time to fertility for individual mares are not required for the BLM to ensure that these methods are humane, safe, and effective, and that herd management goals of achieving and maintaining the AML are met.

Vaccine Formulations: Porcine Zona Pellucida (PZP)
PZP vaccines have been used on dozens of horse herds by the National Park Service, US Forest Service, Bureau of Land Management, and Native American tribes and PZP vaccine use is approved for free-ranging wild and feral horse herds in the United States (EPA, 2012). PZP use can reduce or eliminate the need for gathers and removals, if very high fractions of mares are treated over a very long time period (Turner et al., 1997). PZP vaccines have been used extensively in wild horses (NRC, 2013), and in wild and feral burros (Turner et al., 1996; French et al., 2017; French et al., 2020; Kahler & Boyles-Griffin, 2022). PZP vaccine formulations are produced as ZonaStat-H, an EPA-registered commercial product (EPA, 2012; SCC, 2015), as PZP-22, which is a formulation of PZP in polymer pellets that can lead to a longer immune response (Turner et al., 2002; Rutberg et al., 2017; Grams et al., 2022), and as Spayvac, where the PZP protein is enveloped in liposomes (Killian et al., 2008; Roelle et al., 2017; Bechert & Fraker, 2018; Bechert et al., 2022). ‘Native’ PZP proteins can be purified from pig ovaries (Liu et al., 1989). Recombinant ZP proteins may be produced with molecular techniques (Gupta & Minhas, 2017; Joonè et al., 2017a; Nolan et al., 2018a).

When advisories on the product label (EPA, 2015) are followed, the product is safe for users and the environment (EPA, 2012). In keeping with the EPA registration for ZonaStat-H (EPA, 2012; reg. no. 86833-1), certification through the Science and Conservation Center in Billings Montana is required to apply that vaccine to equids.

For maximum effectiveness, PZP is administered within the December to February timeframe. When applying ZonaStat-H, first the primer with modified Freund’s Complete adjuvant is given and then the booster with Freund’s Incomplete adjuvant is given 2-6 weeks later. Preferably, the timing of the booster dose is at least 1-2 weeks prior to the onset of breeding activity. Following the initial 2 inoculations, only annual boosters are required. For the PZP-22 formulation, each released mare would receive a single dose of the two-year PZP contraceptive vaccine at the same time as a dose of the liquid PZP vaccine with modified Freund’s Complete adjuvant. The pellets are applied to the mare with a large gauge needle and jab-stick into the gluteal muscles (hip). PZP-22 pellets have been successfully delivered via darting (Rutberg et al., 2017; Carey et al., 2019), and could be delivered in that way to approachable mares in Carter Reservoir, Coppersmith, or Buckhorn HMAs.

Vaccine Formulations: Gonadotropin Releasing Hormone (GnRH)
GonaCon (which is produced under the trade name GonaCon-Equine for use in feral horses and burros) is approved for use by authorized federal, state, tribal, public, and private personnel, for application to free-ranging wild horse and burro herds in the United States (EPA, 2013, 2015). GonaCon has been used on feral horses in Theodore Roosevelt National Park and on wild horses administered by BLM. GonaCon has been produced by USDA-APHIS (Fort Collins, Colorado) in several different formulations, the history of which is reviewed by Miller et al. (2013). GonaCon vaccines present the recipient with hundreds of copies of GnRH as peptides on the surface of a linked protein that is naturally antigenic because it comes from invertebrate hemocyanin (Miller et al., 2013). Early GonaCon formulations linked many copies of GnRH to a protein from the keyhole limpet (GonaCon-KHL), but more recently produced formulations where the GnRH antigen is linked to a protein from the blue mussel (GonaCon-B) proved less expensive and more effective (Miller et al., 2008). GonaCon-Equine is in the category of GonaCon-B vaccines.

As with other contraceptives applied to wild horses, the long-term goal of GonaCon-Equine use is to reduce or eliminate the need for gathers and removals (NRC, 2013). GonaCon-Equine contraceptive vaccine is an EPA-approved pesticide (EPA, 2009) that is relatively inexpensive, meets BLM requirements for safety to mares and the environment, and is produced in a USDA-APHIS laboratory. GonaCon is a pharmaceutical-grade vaccine, including aseptic manufacturing technique to deliver a sterile vaccine product (Miller et al., 2013). If stored at 4° C, the shelf life is 6 months (Miller et al., 2013).

Miller et al. (2013) reviewed the vaccine environmental safety and toxicity. When advisories on the product label (EPA, 2015) are followed, the product is safe for users and the environment (EPA, 2009b). EPA waived a number of tests prior to registering the vaccine, because GonaCon was deemed to pose low risks to the environment, so long as the product label is followed (Wang-Cahill et al., 2022).

GonaCon-Equine can safely be reapplied as necessary to control the population growth rate; booster dose effects may lead to increased effectiveness of contraception, which is generally the intent. Even after booster treatment of GonaCon-Equine, it is expected that most, if not all, mares would return to fertility at some point. Although the exact timing for the return to fertility in mares boosted more than once with GonaCon-Equine has not been quantified, a prolonged return to fertility would be consistent with the desired effect of using GonaCon (e.g., effective contraception).

The adjuvant used in GonaCon, Adjuvac, generally leads to a milder reaction than Freund’s Complete Adjuvant (Powers et al., 2011). Adjuvac contains a small number of killed *Mycobacterium avium* cells (Miller et al., 2008; Miller et al., 2013). The antigen and adjuvant are emulsified in mineral oil, such that they are not all presented to the immune system right after injection. It is thought that the mineral oil emulsion leads to a ‘depot effect’ that is associated with slow or sustained release of the antigen, and a resulting longer-lasting immune response (Miller et al., 2013). Miller et al. (2008, 2013) have speculated that, in cases where memory-B leukocytes are protected in immune complexes in the lymphatic system, it can lead to years of immune response. Increased doses of vaccine may lead to stronger immune reactions, but only to a certain point; when Yoder and Miller (2010) tested varying doses of GonaCon in prairie dogs, antibody responses to the 200μg and 400μg doses were equal to each other but were both higher than in response to a 100μg dose.

Direct Effects: PZP Vaccines
The historically accepted hypothesis explaining PZP vaccine effectiveness posits that when injected as an antigen in vaccines, PZP causes the mare’s immune system to produce antibodies that are specific to zona pellucida proteins on the surface of that mare’s eggs. The antibodies bind to the mare’s eggs surface proteins (Liu et al., 1989), and effectively block sperm binding and fertilization (Zoo Montana, 2000). Because treated mares do not become pregnant but other ovarian functions remain generally unchanged, PZP can cause a mare to continue having regular estrus cycles throughout the breeding season. More recent observations support a complementary hypothesis, which posits that PZP vaccination causes reductions in ovary size and function (Mask et al., 2015; Joonè et al., 2017b; Joonè et al., 2017c; Nolan et al., 2018b, 2018c; French et al., 2020). PZP vaccines do not appear to interact with other organ systems, as antibodies specific to PZP protein do not cross react with tissues outside of the reproductive system (Barber & Fayrer-Hosken, 2000).

Research has demonstrated that contraceptive efficacy of an injected liquid PZP vaccine, such as ZonaStat-H, is approximately 90% or more for mares or burros treated twice in the first year (Turner & Kirkpatrick, 2002; Turner et al., 2008; French et al., 2020). In the PopEquus projection model (Folt et al., 2023a, 2023b), a primer and booster dose of PZP ZonaStat-H treatment is modeled as having 95% and 19% reductions on reproduction one and two years after the first two doses, respectively. The same effect is modeled for a third dose, but a higher effectiveness of 95%, 72%, 58% and 30% fertility reductions are modeled for one, two, three, and four years, respectively, after receiving a fourth dose. The highest success for fertility control has been reported when the vaccine has been applied November through February. High contraceptive rates of 90% or more can be maintained in horses that are given a booster dose annually (Kirkpatrick et al., 1992). Approximately 60% to 85% of mares are successfully contracepted for one year when treated simultaneously with a liquid primer and PZP-22 pellets (Rutberg et al., 2017; Carey et al., 2019; Grams et al., 2022). Application of PZP for fertility control would reduce fertility in a large percentage of mares for at least one year (Ransom et al., 2011). The contraceptive result for a single application of the liquid PZP vaccine primer dose along with PZP vaccine pellets (PZP-22), based on winter applications, can be expected to fall in the approximate efficacy ranges as follows (based on Figure 2 in Rutberg et al., 2017). Below, the approximate efficacy used in PopEquus (Folt et al., 2023a, 2023b) modeling for PZP-22 effects is based on available studies and is measured as the relative decrease in foaling rate for treated mares, compared to control mares, with Year 1 having 0% of developing fetuses coming to term, Year 2 having approximately 33 – 72%, and Year 3 having approximately 20 – 40%.

If mares that have been treated with PZP-22 vaccine pellets subsequently receive a booster dose of either the liquid PZP vaccine or the PZP-22 vaccine pellets, the subsequent contraceptive effect is apparently more pronounced and long-lasting. The approximate efficacies following a booster dose can be expected to be in the following ranges with

Year 1 having 0% developing fetuses coming to term, Year 2 having approximately 68 – 85%, Year 3 having approximately 70 – 75%, and Year 4 having approximately 60 – 72% (based on Figure 3 in Rutberg et al. 2017, and used in Folt et al., 2023a, 2023b).

The fraction of mares treated in a herd can have a large effect on the realized change in growth rate due to PZP contraception, with an extremely high portion of mares required over many years to be treated to totally prevent population-level growth (Turner & Kirkpatrick, 2002; Grams et al., 2022). Gather efficiency does not usually exceed 85% via helicopter, and may be less with bait and water trapping, so there would almost always be a portion of the female population uncaptured that is not treated in any given year. Additionally, a small number of mares may not respond to the fertility control vaccine, but instead would continue to foal normally (BLM, 2023).

Direct Effects: GnRH Vaccines

GonaCon-Equine is one of several vaccines that have been engineered to create an immune response to the gonadotropin releasing hormone peptide (GnRH). GnRH is a small peptide that plays an important role in signaling the production of other hormones involved in reproduction in both sexes. When combined with an adjuvant, a GnRH vaccine stimulates a persistent immune response resulting in prolonged antibody production against GnRH, the carrier protein, and the adjuvant (Miller et al., 2008). The most direct result of successful GnRH vaccination is that it has the effect of decreasing the level of GnRH signaling in the body, as evidenced by a drop in luteinizing hormone levels, and a cessation of ovulation.

GnRH is highly conserved across mammalian taxa, so some inferences about the mechanism and effects of GonaCon-Equine in horses can be made from studies that used different anti-GnRH vaccines, in horses and other taxa. Other commercially available anti-GnRH vaccines include: Improvac (Imboden et al., 2006; Botha et al., 2008; Schulman et al., 2013; Dalmau et al., 2015; Nolan et al., 2018c), made in South Africa; Equity (Elhay et al., 2007), made in Australia; Improvest, for use in swine (Bohrer et al., 2014); Repro-BLOC (Boedeker et al., 2012); and Bopriva, for use in cows (Balet et al., 2014). Of these, GonaCon-Equine, Improvac, and Equity are specifically intended for horses. Other anti-GnRH vaccine formulations have also been tested, but did not become trademarked products (Goodloe, 1991; Dalin et al., 2002; Stout et al., 2003; Donovan et al., 2013; Schaut et al., 2018; Yao et al., 2018). The effectiveness and side-effects of these various anti-GnRH vaccines may not be the same as would be expected from GonaCon-Equine use in horses. Results could differ as a result of differences in the preparation of the GnRH antigen, and the choice of adjuvant used to stimulate the immune response. For some formulations of anti-GnRH vaccines, a booster dose is required to elicit a contraceptive response, though GonaCon can cause short-term contraception in a fraction of treated animals from one dose (Powers et al., 2011; Gionfriddo et al., 2011a; Baker et al., 2013; Miller et al., 2013).

GonaCon can provide multiple years of infertility in several wild ungulate species, including horses (Killian et al., 2008; Gray et al., 2010). The lack of estrus cycling that results from successful GonaCon vaccination has been compared to typical winter period of anoestrus in open mares. As anti-GnRH antibodies decline over time, concentrations of available endogenous GnRH increase and treated animals usually regain fertility (Power et al., 2011). In the PopEquus projection model (Folt et al., 2023a, 2023b), a single dose of GonaCon-equine treatment is modeled as having 37% and 29% reductions on reproduction one and two years; as with the PZP ZonaStat-H vaccine, GonaCon is not expected to reduce the foaling rate for existing pregnancies. The PopEquus model (Folt et al., 2023a, 2023b) models fertility reductions of 100%, 85%, and 50% respectively for years 1, 2–4, and 5–7 years after two or more doses. Unpublished results indicate that BLM-managed wild horses that were treated with a primer dose, held for 30 days, and treated with a booster dose before being returned to the range foaled at normal rates in the first season after treatment, but then had contraceptive effectiveness of approximately 85%. Those results are based on observations in three HMAs. Mares were initially treated in September 2020 (Sulphur and Swasey HMAs) or January 2021 (Eagle HMA), held until they received a booster dose of GonaCon-equine, then released. Some mares were radio-collared (Schoenecker et al., 2020) or radio-tail-tagged (King et al., 2022) before release. After release, mares were monitored visually at least once per month to document any foaling and to confirm that radio collars were not causing any negative effects to the mares. Because of the timing of vaccination, it is not expected that there would have been any reduction in foaling in 2021, as GonaCon-equine is not expected to influence the fetus of any mares that were pregnant at the time of vaccination. For these mares, 2022 was the first year when the GonaCon-equine could have had a contraceptive effect; 8 of the 59 treated mares (~14%) were observed to have a foal. 2023 was the second year of potentially observable contraceptive effect, and approximately 30% of mares were observed to have foals.

Baker et al. (2018) showed that mares which receive only one dose of GonaCon-Equine tend to return to fertility within 3 years. Baker et al. (2018, 2023) have also shown that mares treated twice with GonaCon-Equine return to fertility over time, with an increasing number of mares returning to fertility the longer the time since the second dose. The specific method of injection and the time between the first and second dose appear to influence the effectiveness. Two hand-injected doses 4 years apart caused 100% infertility for a year, but that had dropped to 80% by year 6. Two darted injections separated by 6 months, 1 year, or 2 years appear less effective: within 3-4 years after two darted injections, only between about 55% to 75% of mares were infertile. When two hand-injections were only separated by 30 days, approximately 85% of treated mares were infertile for 1 year (BLM, 2022); this is more effective than one dose, but less effective than when the doses are separated by 4 years. This 30-day timing is becoming a relatively common treatment schedule and is consistent with the EPA label for this vaccine (EPA, 2013).

As is true for PZP vaccine treatments, the fraction of mares treated in a herd can have a large effect on the realized change in growth rate. Due to high wild horse survival rates, in any given year, a very high fraction of mares (i.e. ~75%) must be effectively contracepted (i.e., the fertility control vaccine prevents fertility in that year) to cause overall herd-level growth rates to be anywhere close to zero. The fraction of contracepted mares at any given time has also been called the 'fertility control index' (Grams et al., 2022; Schulman et al., 2024). As part of its adaptive management in decisions about how many mares to treat with fertility control vaccine in any given year of the 10-year proposed duration of this action, the BLM would use results of monitoring to make inferences about the number of mares present and the expected fraction of those that may be effectively contracepted, based on their treatment histories. Due to logistical limitation in these herds, it is expected that there would almost always be a sizeable portion of the female population that is fertile in any given year. However, ongoing monitoring of herd size and foal to adult ratios, along with mare fertility control treatment records and updated population modeling with PopEquus would be informative in BLM decisions about how many additional fertility control treatments might be desirable in any given year, in each of the HMAs analyzed in the EA.

Females that are successfully contracepted by GnRH vaccination enter a state similar to anestrus, have a lack of or incomplete follicle maturation, and no ovarian cycling (Botha et al., 2008; Nolan et al., 2018c). A leading hypothesis is that anti-GnRH antibodies bind GnRH in the hypothalamus – pituitary 'portal vessels,' preventing GnRH from binding to GnRH-specific binding sites on gonadotroph cells in the pituitary, thereby limiting the production of gonadotropin hormones, particularly luteinizing hormone (LH) and, to a lesser degree, follicle-stimulating hormone (FSH) (Powers et al., 2011; NRC, 2013). This reduction in LH (and FSH), and a corresponding lack of ovulation, has been measured in response to treatment with anti-GnRH vaccines (Boedeker et al., 2012; Garza et al., 1986).

Females successfully treated with anti-GnRH vaccines have reduced progesterone levels (Garza et al., 1986; Stout et al., 2003; Imboden et al., 2006; Elhay et al., 2007; Botha et al., 2008; Killian et al., 2008; Miller et al., 2008; Schulman et al., 2013; Balet et al., 2014; Dalmau et al., 2015) and β-17 estradiol levels (Elhay et al., 2007), but no great decrease in estrogen levels (Balet et al., 2014). Reductions in progesterone do not occur immediately after the primer dose but can take several weeks or months to develop (Elhay et al., 2007; Botha et al., 2008; Schulman et al., 2013; Dalmau et al., 2015). This indicates that ovulation is not occurring and corpora lutea, formed from post-ovulation follicular tissue, are not being established.

Antibody titer measurements are proximate measures of the antibody concentration in the blood specific to a given antigen. Anti-GnRH titers generally correlate with a suppressed reproduction system (Gionfriddo et al., 2011a; Powers et al., 2011). Various studies have attempted to identify a relationship between anti-GnRH titer levels and infertility, but that relationship has not been universally predictable or consistent. The time length that titer levels stay high appears to correlate with the length of suppressed reproduction (Dalin et al., 2002; Levy et al., 2011; Donovan et al., 2013; Powers et al., 2011). For example, Goodloe (1991) noted that mares did produce elevated titers and had suppressed follicular development for 11-13 weeks after treatment, but that all treated mares ovulated after the titer levels declined. Similarly, Elhay et al. (2007) found that high initial titers correlated with longer-lasting ovarian and behavioral anoestrus. However, Powers et al. (2011) did not identify a threshold level of titer that was consistently indicative of suppressed reproduction despite seeing a strong correlation between antibody concentration and infertility, nor did Schulman et al. (2013) find a clear relationship between titer levels and mare acyclicity.

In many cases, young animals appear to have higher immune responses, and stronger contraceptive effects of anti-GnRH vaccines than older animals (Brown et al., 1994; Curtis et al., 2002; Stout et al., 2003; Schulman et al., 2013). Vaccinating with GonaCon at too young an age, though, may prevent effectiveness; Gionfriddo et al. (2011a) observed weak effects in 3–4-month-old fawns. It has not been possible to predict with precision which individuals of a given age class would have long-lasting immune responses to the GonaCon vaccine. Gray (2009) noted that mares in poor body condition tended to have lower contraceptive efficacy in response to GonaCon-B. Miller et al. (2013) suggested that higher parasite loads might have explained a lower immune response in free-roaming horses than had been observed in a captive trial. At this time, it is unclear what the quantitative relationship is between various factors and the resulting contraceptive efficacy, but average efficacy rates have been reported in studies such as Baker et al. (2023).

Several studies have monitored animal health after immunization against GnRH. GonaCon treated mares did not have any measurable difference in uterine edema (Killian et al., 2006; Killian et al., 2008). Powers et al. (2011, 2013) noted no differences in blood chemistry except a mildly elevated fibrinogen level in some GonaCon treated elk. In that study, one sham-treated elk and one GonaCon treated elk each developed leukocytosis, suggesting that there may have been a causal link between the adjuvant and the effect. Curtis et al. (2008) found persistent granulomas at GonaCon-KHL injection sites three years after injection, and reduced ovary weights in treated females. Yoder and Miller (2010) found no difference in blood chemistry between GonaCon treated and control prairie dogs. One of 15 GonaCon treated cats died without explanation, and with no determination about cause of death possible based on necropsy or histology (Levy et al., 2011). Other anti-GnRH vaccine formulations have led to no detectable adverse effects (in elephants; Boedeker et al., 2012), though Imboden et al. (2006) speculated that treating young animals might conceivably have impaired hypothalamic or pituitary function.

Kirkpatrick et al. (2011) raised concerns that anti-GnRH vaccines could lead to adverse effects in other organ systems outside the reproductive system. GnRH receptors have been identified in tissues outside of the pituitary system, including in the testes and placenta (Khodr & Siler-Khodr, 1980), ovary (Hsueh & Erickson, 1979), bladder (Coit et al., 2009), heart (Dong et al., 2011), and central nervous system, so it is plausible that reductions in circulating GnRH levels could inhibit physiological processes in those organ systems. Kirkpatrick et al. (2011) noted elevated cardiological risks to human patients taking GnRH agonists (such as leuprolide), but the National Academy of Sciences (2013) concluded that the mechanism and results of GnRH agonists would be expected to be different from that of anti-GnRH antibodies; the former flood GnRH receptors, while the latter deprive receptors of GnRH.

Return to Fertility and Effects on Ovaries: PZP Vaccines
In most cases, PZP contraception appears to be temporary and most treated mares return to fertility over time (Kirkpatrick & Turner, 2002) unless they receive additional vaccine treatments. The return to fertility associated with a reduced immune response to the fertility control vaccine antigen has been called ‘reversibility,’ but the timing of the return to fertility is not under direct human control in the same sense that a narcotic drug can be reversed by application of naloxone, for example. The ZonaStat-H formulation of the vaccine tends to confer only one year of efficacy per dose. Some studies have found that a PZP vaccine in long-lasting pellets (PZP-22) can confer multiple years of contraception (Turner et al., 2007), particularly when boostered with subsequent PZP vaccination (Rutberg et al., 2017). Other trial data, though, indicate that the pelleted vaccine may only be effective for one year (J. Turner, University of Toledo, Personal Communication to BLM).

The purpose of applying PZP vaccine treatment is to prevent mares or jennies from conceiving foals, but BLM acknowledges that long-term infertility could be a result for some number of individual wild horses receiving PZP vaccinations. The effect of the PZP vaccine treatments is an immune response but if it happens that multiple PZP vaccine treatments cause a mare to not regain fertility before death, some would interpret that course of immunocontraceptive treatment to have caused sterility. The rate of long-term or permanent sterility following vaccinations with PZP is hard to predict for individual horses, but that outcome appears to increase in likelihood as the number of doses increases (Kirkpatrick & Turner, 2002). This form of vaccine-induced long-term infertility or sterility for mares treated consecutively in each of 5-7 years was observed by Nuñez et al. (2010, 2017). In a graduate thesis, Knight (2014) suggested that repeated treatment with as few as three to four years of PZP treatment may lead to longer-term sterility, and that sterility may result from PZP treatment before puberty. Repeated treatment with PZP led long-term infertility in Przewalski's horses receiving as few as one PZP booster dose (Feh, 2012). However, even if some number of mares become sterile as a result of PZP treatment, that potential result would be consistent with the contraceptive purpose that motivates BLM's potential use of the vaccine, and with Congressional guidance that condones such treatment in the management of wild horses and burros, in WFRHBA section 1333(b).

In some number of individual mares and jennies, PZP vaccination may cause direct effects on ovaries (Gray & Cameron, 2010; Joonè et al., 2017b; Joonè et al., 2017c; Nolan et al., 2018b; French et al., 2020). Joonè et al. (2017a) noted that effects on ovaries in mares treated with one primer dose and booster dose were temporary. Joonè et al. (2017c) and Nolan et al. (2018b) documented decreased anti-Mullerian hormone (AMH) levels in mares treated with native or recombinant PZP vaccines; AMH levels are thought to be an indicator of ovarian function. French et al. (2020) documented fewer visible follicles and reduced uterine horn diameter in PZP treated jennies; 25% of treated burros returned to fertility during that study. Bechert et al. (2013) found that ovarian function was affected by the SpayVac PZP vaccination, but that there were no effects on other organ systems. Mask et al. (2015) demonstrated that equine antibodies that resulted from SpayVac immunization could bind to oocytes, ZP proteins, follicular tissues, and ovarian tissues. It is possible that result is specific to the immune response to SpayVac, which may have lower PZP purity than ZonaStat or PZP-22 (Hall et al., 2016). However, in studies with native ZP proteins and recombinant ZP proteins, Joonè et al. (2017a) found transient effects on ovaries after PZP vaccination in some treated mares; normal estrus cycling had resumed 10 months after the last treatment. SpayVac is a patented formulation of PZP in liposomes that led to multiple years of infertility in some breeding trials (Killian et al., 2008; Roelle et al., 2017; Bechert & Fraker, 2018), but unacceptably poor efficacy in a subsequent trial (Kane, 2018). Kirkpatrick et al. (1992) noted effects on horse ovaries after three years of treatment with PZP. Observations at Assateague Island National Seashore indicated that the more times a mare is consecutively treated, the longer the time lag before fertility returns, but that even mares treated 7 consecutive years did eventually return to ovulation (Kirkpatrick & Turner, 2002). Other studies have reported that continued PZP vaccine applications may result in decreased estrogen levels (Kirkpatrick et al., 1992) but that decrease was not biologically significant, as ovulation remained similar between treated and untreated mares (Powell & Monfort, 2001). Skinner et al. (1984) raised concerns about PZP effects on ovaries, based on their study in laboratory rabbits, as did Kaur and Prabha (2014), though neither paper was a study on the effects of PZP in equids. Bagavant et al. (2002) demonstrated T-cell clusters on ovaries, but no loss of ovarian function after ZP protein immunization in macaques.

Return to Fertility and Effects on Ovaries: GnRH Vaccines
As with PZP vaccines, mares that are treated with GonaCon-equine vaccine can be expected to return to fertility when the immune response to the antigen declines; in the colloquial usage of the term, this also makes GonaCon-equine a 'reversible' treatment, even though the return to fertility is not under direct human control in the same sense that a narcotic drug can be 'reversed' by application of naloxone, for example. The NRC (2013) review pointed out that single doses of GonaCon-Equine do not lead to high rates of initial effectiveness, or long duration. Initial effectiveness of one dose of GonaCon-Equine vaccine appears to be lower than for a combined primer plus booster dose of the PZP vaccine Zonastat-H (Kirkpatrick et al., 2011), and the initial effect of a single GonaCon dose can be limited to as little as one breeding season; a relatively ow fraction of mares that receive only one dose of GonaCon-equine may be contracepted in the first year after treatment. However, preliminary results on the effects of boostered doses of GonaCon-Equine indicate that a booster dose in horses can increase the strength and duration of immune response – this can result in high contraceptive efficacy and longer-lasting effects (Baker et al., 2017, 2018) than the one-year effect that is generally expected from a single booster of Zonastat-H.

Too few studies have reported on the various formulations of anti-GnRH vaccines to make generalizations about differences between products, but GonaCon formulations were consistently good at causing loss of fertility in a statistically significant fraction of treated mares for at least one year (Killian et al., 2009; Gray et al., 2010; Baker et al., 2013, 2017, 2018). With few exceptions (Goodloe, 1991), anti-GnRH treated mares gave birth to fewer foals in the first season when there would be an expected contraceptive effect (Botha et al., 2008; Killian et al., 2009; Gray et al., 2010; Baker et al., 2013, 2018). Goodloe (1991) used an anti-GnRH-KHL vaccine with a triple adjuvant, in some cases attempting to deliver the vaccine to horses with a hollow-tipped ‘biobullet, ’but concluded that the vaccine was not an effective immunocontraceptive in that study.

Not all mares should be expected to respond to the GonaCon-equine vaccine; some number should be expected to continue to become pregnant and give birth to foals. In studies where mares were exposed to stallions, the fraction of treated mares that are effectively contracepted in the year after anti-GnRH vaccination varied from study to study, ranging from ~50% (Baker et al., 2017), to 61% (Gray et al., 2010), to ~90% (Killian et al., 2006, 2008, 2009). Miller et al. (2013) noted lower effectiveness in free-ranging mares (Gray et al., 2010) than captive mares (Killian et al., 2009). Some of these rates are lower than the high rate of effectiveness typically reported for the first year after PZP vaccine treatment (Kirkpatrick et al., 2011). In the one study that tested for a difference, darts, and hand injected GonaCon doses were equally effective in terms of short-term fertility outcome (McCann et al., 2017). After treatment with GonaCon-equine vaccine, some mares may return to fertility faster than others (Thompson et al., 2022).

In studies where mares were not exposed to stallions, the duration of effectiveness also varied. A primer and booster dose of Equity led to anoestrus for at least 3 months (Elhay et al., 2007). A primer and booster dose of Improvac also led to loss of ovarian cycling for all mares in the short term (Imboden et al., 2006; Nolan et al., 2018c). It is worth repeating that those vaccines do not have the same formulation as GonaCon.

Results from horses (Baker et al., 2017, 2018, 2023) and other species (Curtis et al., 2002) suggest that providing a booster dose of GonaCon-Equine would increase the fraction of temporarily infertile animals to higher levels than would a single vaccine dose alone.

Longer-term infertility has been observed in some mares treated with anti-GnRH vaccines, including GonaCon-Equine. In a single-dose mare captive trial with an initial year effectiveness of 94%, Killian et al. (2008) noted infertility rates of 64%, 57%, and 43% in treated mares during the following three years, while control mares in those years had infertility rates of 25%, 12%, and 0% in those years. GonaCon effectiveness in free-roaming populations was lower, with infertility rates consistently near 60% for three years after a single dose in one study (Gray et al., 2010) and annual infertility rates decreasing over time from 55% to 30% to 0% in another study with one dose (Baker et al., 2017, 2018). Similarly, gradually increasing fertility rates were observed after single dose treatment with GonaCon in elk (Powers et al., 2011) and deer (Gionfriddo et al., 2011a); these results are consistent with the expectation that contraceptive effect of GonaCon in mammals results from the immune response, and that return to fertility increases as that immune response wanes.

Baker et al. (2017, 2018) observed a return to fertility over 4 years in mares treated once with GonaCon, but then noted extremely low fertility rates of 0% and 16% in the two years after the same mares were given a booster dose four years after the primer dose. Four of nine mares treated with primer and booster doses of Improvac did not return to ovulation within 2 years of the primer dose (Imboden et al., 2006), though one should probably not make conclusions about the long-term effects of GonaCon-Equine based on results from Improvac. In 2023, Baker et al. reported that mares treated with two doses of GonaCon-Equine returned to fertility at different rates and timing, depending on the length of time between the primer and booster dose. The longer the time between primer and booster, generally the longer-lasting was the contraceptive effect. For mares re-treated 4 years after the first dose, 29% had returned to fertility within 6 years after the second dose. For mares re-treated 2 years after the first dose, 36% had returned to fertility within 4 years of the second dose. For mares retreated 1 year, or 6 months after their first dose, 57%, and 46% of mares, respectively, had returned to fertility within 3 years. Results for the timing of return to fertility among mares treated twice with GonaCon-Equine vaccine is consistent with immune response being the cause of contraception, and that those contraceptive effects wane as the immune response declines over time (Baker et al., 2023).

It is difficult to predict which females would exhibit strong or long-term immune responses to anti-GnRH vaccines (Killian et al., 2006; Miller et al., 2008; Levy et al., 2011). A number of factors may influence responses to vaccination, including age, body condition, nutrition, prior immune responses, and genetics (Cooper & Herbert, 2002; Curtis et al., 2002; Powers et al., 2011; Thompson et al., 2022). One apparent trend is that animals that are treated at a younger age, especially before puberty, may have stronger and longer-lasting responses (Brown et al., 1994; Curtis et al., 2002; Stout et al., 2003; Schulman et al., 2013). It is plausible that giving ConaGon-Equine to prepubertal mares would lead to long-lasting infertility, but no published data are available. However, it is expected that it would be extremely rare that prepubertal mares would be treated with GonaCon and returned to the range, and more likely that it would not happen at all, considering that such young animals also tend to be highly adoptable.

To date, short term evaluation of anti-GnRH vaccines, show contraception appears to be temporary, and a result of an immune response that can wane over time. Killian et al. (2009) noted long-term effects of GonaCon in some captive mares. However, Baker et al. (2017) observed horses treated with GonaCon-B return to fertility after they were treated with a single primer dose; after four years, the fertility rate was indistinguishable between treated and control mares. It appears that a single dose of GonaCon results in temporary infertility lasting a short time (i.e., usually less than 2 years). Baker et al. (2023) noted the possibility that some mares treated twice with GonaCon-Equine vaccine could remain contracepted for over 6 years, or even until they die; the latter outcome would presumably depend on the animal's age when treated, with older animals more likely to die before regaining fertility simply because their lifespan may not be long enough for the immune reaction to wane and cause a resumption of fertility. If long-term treatment resulted in such a long duration of immune response that a mare remains infertile until death, that type of permanent infertility would be consistent with the desired effect of using GonaCon (e.g., effective contraception), and with section 1333(b) of the WFRHBA.

Other anti-GnRH vaccines also have had temporary effects in mares. Elhay et al. (2007) noted a return to ovary functioning over the course of 34 weeks for 10 of 16 mares treated with Equity. That study ended at 34 weeks, so it is not clear when the other six mares would have returned to fertility. Donovan et al. (2013) found that half of mares treated with an anti-GnRH vaccine intended for dogs had returned to fertility after 40 weeks, at which point the study ended. In a study of mares treated with a primer and booster dose of Improvac, 47 of 51 treated mares had returned to ovarian cyclicity within 2 years; younger mares appeared to have longer-lasting effects than older mares (Schulman et al., 2013). Joonè et al. (2017) analyzed samples from the Schulman et al. (2013) study and found no significant decrease in anti-Mullerian hormone (AMH) levels in mares treated with GnRH vaccine. AMH levels are thought to be an indicator of ovarian function, so results from Joonè et al. (2017) support the general view that the anoestrus resulting from GnRH vaccination is physiologically similar to typical winter anoestrus. In a small study with a non-commercial anti-GnRH vaccine (Stout et al., 2003), three of seven treated mares had returned to cyclicity within 8 weeks after delivery of the primer dose, while four others were still suppressed for 12 or more weeks. In elk, Powers et al. (2011) noted that contraception after one dose of GonaCon was temporary. In white-tailed deer, single doses of GonaCon appeared to confer two years of contraception (Miller et al., 2000). Ten of 30 domestic cows treated became pregnant within 30 weeks after the first dose of Bopriva (Balet et al., 2014).

Long-term infertility could result from multiple doses of GonaCon-equine vaccine. As is the case for PZP vaccines (noted above), it is possible that some fraction of mares treated with multiple doses of GonaCon-equine could be prevented from having any more foals before they die – this outcome would depend on the age when the mare is treated, duration of the mare's immune response, and the mare's longevity. All available evidence supports the conclusion that the effect of GonaCon-equine vaccine treatments is to cause an immune response, and that when that immune response wanes a mare is expected to return to fertility. As noted above, Baker et al. (2023) demonstrated increasing rates of return to fertility over time, after a second dose of GoanCon-Equine was administered. But if it happens that GonaCon-equine vaccine treatments cause a mare or jenny to not return to fertility before death, some would interpret that course of immunocontraceptive treatment to have caused sterility. If some fraction of mares or jennies treated with GonaCon-Equine were to become sterile, though, that result would be consistent with the contraceptive purpose that motivates BLM's potential use of the vaccine, and with Congressional guidance that condones such treatment in the management of wild horses and burros, in WFRHBA section 1333(b).

In summary, based on the above results related to fertility effects of GonaCon and other anti-GnRH vaccines, application of a single dose of GonaCon-Equine to gathered or remotely darted wild horses could be expected to prevent pregnancy in perhaps 30%-60% of mares for one year. Some smaller number of wild mares should be expected to have persistent contraception for a second year, and less still for a third year. Applying one booster dose of GonaCon to previously treated mares may lead to four or more years with relatively high rates (80+%) of additional infertility expected (Baker et al., 2018, 2023), with the potential for additional infertility until the immune response to the vaccine wears off. The duration of effect after a second dose would appear to depend on the length of time between first and second dose, with longer-lasting effects if that time span is 4 years than if it is 1 year or less (Baker et al., 2023). Given that GonaCon-Equine is formulated as a highly immunogenic long-lasting vaccine, it is reasonable to hypothesize that additional boosters would increase the effectiveness and duration of the vaccine.

GonaCon-Equine only affects the fertility of treated animals; untreated animals would still be expected to give birth. Even under favorable circumstances for population growth suppression, gather efficiency might not exceed 85% via helicopter, and may be less with bait and water trapping. Similarly, not all animals may be approachable for darting. The uncaptured or undarted portion of the female population would still be expected to have normally high fertility rates in any given year, though those rates could go up slightly if contraception in other mares increases forage and water availability.

Changes in hormones associated with anti-GnRH vaccination led to measurable changes in ovarian structure and function. The volume of ovaries reduced in response to treatment (Garza et al., 1986; Dalin et al., 2002; Imboden et al., 2006; Elhay et al., 2007; Botha et al., 2008; Gionfriddo, 2011a; Dalmau et al., 2015). Treatment with an anti-GnRH vaccine changes follicle development (Garza et al., 1986; Stout et al., 2003; Imboden et al., 2006; Elhay et al., 2007; Donovan et al., 2013; Powers et al., 2011; Balet et al., 2014), with the result that ovulation does not occur. A related result is that the ovaries can exhibit less activity and cycle with less regularity or not at all in anti-GnRH vaccine treated females (Goodloe, 1991; Dalin et al., 2002; Imboden et al., 2006; Elhay et al., 2007; Powers et al., 2011; Donovan et al., 2013). In studies where the vaccine required a booster, hormonal and associated results were generally observed within several weeks after delivery of the booster dose.

Effects on Existing Pregnancies, Foals, and Birth Phenology: PZP Vaccines

Although fetuses are not explicitly protected under the WFRHBA of 1971, as amended, it is prudent to analyze the potential effects of fertility control vaccines on developing fetuses and foals. Any impacts identified in the literature have been found to be transient, and do not influence the future reproductive capacity of offspring born to treated females.

If a mare is already pregnant, the PZP vaccine has not been shown to affect normal development of the fetus or foal, or the hormonal health of the mare with relation to pregnancy (Kirkpatrick & Turner, 2003). Studies on Assateague Island (Kirkpatrick & Turner, 2002) showed that once female offspring born to mares treated with PZP during pregnancy eventually breed, they produce healthy, viable foals. It is possible that there may be transitory effects on foals born to mares or jennies treated with PZP. For example, in mice, Sacco et al. (1981) found that antibodies specific to PZP can pass from mother mouse to pup via the placenta or colostrum, but that did not apparently cause any innate immune response in the offspring: the level of those antibodies were undetectable by 116 days after birth. There was no indication in that study that the fertility or ovarian function of those mouse pups was compromised, nor is BLM aware of any such results in horses or burros. Unsubstantiated, speculative connections between PZP treatment and ‘foal stealing’ has not been published in a peer-reviewed study and thus cannot be verified. ‘Foal stealing,’ where a near-term pregnant mare steals a neonate foal from a weaker mare, is unlikely to be a common behavioral result of including spayed mares in a wild horse herd. McDonnell (2012) noted that “foal stealing is rarely observed in horses, except under crowded conditions and synchronization of foaling,” such as in horse feed lots. Those conditions are not likely in the wild, where pregnant mares would be widely distributed across the landscape, and where the expectation is that parturition dates would be distributed across the normal foaling season. Similarly, although Nettles (1997) noted reported stillbirths after PZP treatments in cynomolgus monkeys, those results have not been observed in equids despite extensive use in horses and burros.

On-range observations from 20 years of application to wild horses indicate that PZP application in wild mares does not generally cause mares to give birth to foals out of season or late in the year (Kirkpatrick and Turner 2003). Research by Nuñez et al. (2010) showed that a small number of mares that had previously been treated with PZP foaled later than untreated mares and expressed the concern that this late foaling “may” impact foal survivorship and decrease band stability, or that higher levels of attention from stallions on PZP-treated mares might harm those mares. However, that paper provided no evidence that such impacts on foal survival or mare well-being actually occurred. Rubenstein (1981) called attention to a number of unique ecological features of horse herds on Atlantic barrier islands, such as where Nuñez et al. made observations, which calls into question whether inferences drawn from island herds can be applied to western wild horse herds. Ransom et al. (2013), though, did identify a potential shift in reproductive timing as a possible drawback to prolonged treatment with PZP, stating that treated mares foaled on average 31 days later than non-treated mares. Results from Ransom et al. (2013), however, showed that over 81% of the documented births in that study were between March 1 and June 21, i.e., within the normal, peak, spring foaling season. Ransom et al. (2013) pointedly advised that managers should consider carefully before using fertility control vaccines in small refugia or rare species. Wild horses and burros managed by BLM do not generally occur in isolated refugia, nor are they at all rare species. The US Fish and Wildlife Service denied a petition to list wild horses as endangered (USFWS, 2015). Moreover, any effect of shifting birth phenology was not observed uniformly: in two of three PZP-treated wild horse populations studied by Ransom et al. (2013), foaling season of treated mares extended three weeks and 3.5 months, respectively, beyond that of untreated mares. In the other population, the treated mares foaled within the same time period as the untreated mares. Furthermore, Ransom et al. (2013) found no negative impacts on foal survival even with an extended birthing season. If there are shifts in birth phenology, though, it is reasonable to assume that some negative effects on foal survival for a small number of foals might result from particularly severe weather events (Nuñez, 2018).

Effects on Existing Pregnancies, Foals, and Birth Phenology: GnRH Vaccines
Although fetuses are not explicitly protected under the WFRHBA of 1971, as amended, it is prudent to analyze the potential effects of fertility control vaccines on developing fetuses and foals. Any impacts identified in the literature have been found to be transient, and do not influence the future reproductive capacity of offspring born to treated females.

GonaCon and other anti-GnRH vaccines can be injected while a female is pregnant (Miller et al., 2000; Powers et al., 2011; Baker et al., 2013) – in such a case, a successfully contracepted mare would be expected to give birth during the following foaling season, but to be infertile during the same year’s breeding season. Thus, a mare injected in November of 2018 would not show the contraceptive effect (i.e., no new foal) until spring of 2020.

GonaCon had no apparent effect on pregnancies in progress, foaling success, or the health of offspring, in horses that were immunized in October (Baker et al., 2013), elk immunized 80-100 days into gestation (Powers et al., 2011, 2013), or deer immunized in February (Miller et al., 2000). Kirkpatrick et al. (2011) noted that anti-GnRH immunization is not expected to cause hormonal changes that would lead to abortion in the horse, but this may not be true for the first 6 weeks of pregnancy (NRC, 2013). Curtis et al. (2002) noted that GonaCon-KHL treated white tailed deer had lower twinning rates than controls but speculated that the difference could be due to poorer sperm quality late in the breeding season, when the treated does did become pregnant. Goodloe (1991) found no difference in foal production between treated and control animals.

Offspring of anti-GnRH vaccine treated mothers could exhibit an immune response to GnRH (Khodr & Siler-Khodr, 1980), as antibodies from the mother could pass to the offspring through the placenta or colostrum. In the most extensive study of long-term effects of GonaCon immunization on offspring, Powers et al. (2012) monitored 15 elk fawns born to GonaCon treated cows. Of those, 5 had low titers at birth and 10 had high titer levels at birth. All 15 were of normal weight at birth, and developed normal endocrine profiles, hypothalamic GnRH content, pituitary gonadotropin content, gonad structure, and gametogenesis. All the females became pregnant in their second reproductive season, as is typical. All males showed normal development of secondary sexual characteristics. Powers et al. (2012) concluded that suppressing GnRH in the neonatal period did not alter long-term reproductive function in either male or female offspring. Miller et al. (2013) report elevated anti-GnRH antibody titers in fawns born to treated white tailed deer, but those dropped to normal levels in 11 of 12 of those fawns, which came into breeding condition; the remaining fawn was infertile for three years.

Direct effects on foal survival are equivocal in the literature. Goodloe (1991) reported lower foal survival for a small sample of foals born to anti-GnRH treated mares but did not assess other possible explanatory factors such as mare social status, age, body condition, or habitat (NRC, 2013). Gray et al. (2010) found no difference in sex ratio, parturition phenology, or foal survival in foals born to free-roaming mares treated with GonaCon.

There is little empirical information available to evaluate the effects of GnRH vaccination on foaling phenology, but those effects are likely to be similar to those for PZP vaccine treated mares in which the effects of the vaccine wear off. It is possible that immunocontracepted mares returning to fertility late in the breeding season could give birth to foals at a time that is out of the normal range (Nuñez et al., 2010; Ransom et al., 2013). Curtis et al. (2002) did observe a slightly later fawning date for GonaCon treated deer in the second year after treatment, when some does regained fertility late in the breeding season. In anti-GnRH vaccine trials in free-roaming horses, there were no published differences in mean date of foal production (Goodloe, 1991; Gray et al., 2010). Baker et al. (2023) reported a wider range of foaling dates in mares treated with GonaCon-Equine vaccine than in untreated mares, but the differences in foaling date were not associated with any difference in foal survival rates. Because of the concern that contraception could lead to shifts in the timing of parturitions for some treated animals, Ransom et al. (2013) advised that managers should consider carefully before using PZP immunocontraception in small refugia or rare species; the same considerations could be advised for use of GonaCon, but wild horses and burros in most areas do not generally occur in isolated refugia, they are not a rare species at the regional, national, or international level, and genetically they represent descendants of domestic livestock with most populations containing few if any unique alleles (NRC, 2013). Moreover, in PZP-treated horses that did have some degree of parturition date shift, Ransom et al. (2013) found no negative impacts on foal survival even with an extended birthing season; however, this may be more related to stochastic, inclement weather events than extended foaling seasons. If there were to be a shift in foaling date for some treated mares, the effect on foal survival may depend on weather severity and local conditions; for example, Ransom et al. (2013) did not find consistent effects across study sites.

Effects of Marking and Injection

Standard practices require that immunocontraceptive-treated animals be readily identifiable, either via brand marks or unique coloration (BLM, 2010). Some level of transient stress is likely to result in newly captured mares that do not have markings associated with previous fertility control treatments. It is difficult to compare that level of temporary stress with the long-term stress that can result from food and water limitation on the range (Creel et al., 2013).

Handling may include freeze-marking and / or RFID chipping, for the purpose of identifying that mare and identifying that mare's vaccine treatment history. Under past management practices, captured mares experienced increased stress levels from handling (Ashley & Holcombe, 2001), but BLM has instituted guidelines to reduce the sources of handling stress in captured animals (BLM, 2021).

Most mares recover from the stress of capture and handling quickly once released back to the range, and none are expected to suffer serious long-term effects from the fertility control injections, other than the direct consequence of becoming temporarily infertile. Injection site reactions associated with fertility control treatments are possible in treated mares and jennies (Roelle & Ransom, 2009; Bechert et al., 2013; French et al., 2017; Baker et al., 2018; French et al., 2020), but swelling or local reactions at the injection site are expected to be minor in nature. Roelle and Ransom (2009) found that the most time-efficient method for applying PZP is by hand-delivered injection of 2-year pellets when horses are gathered. They observed only two instances of swelling from that technique. French et al. (2020) observed localized swelling, transient lameness in PZP vaccine-treated burros, and sterile abscesses in 87% of those treated jennies. Whether injection is by hand or via darting, GonaCon-Equine is associated with some degree of inflammation, swelling, and the potential for abscesses at the injection site (Baker et al., 2013). Swelling or local reactions at the injection site are generally expected to be minor in nature, but some may develop into draining abscesses. Use of remotely delivered vaccine is generally limited to populations where individual animals can be accurately identified and repeatedly approached. The dart-delivered PZP formulation produced injection-site reactions of varying intensity, though none of the observed reactions appeared debilitating to the animals (Roelle & Ransom, 2009) but that was not observed with dart-delivered GonaCon (McCann et al., 2017). Joonè et al. (2017a) found that injection site reactions had healed in most mares within 3 months after the booster dose, and that they did not affect movement or cause fever.

Long-lasting nodules observed did not appear to change any animal's range of movement or locomotor patterns and in most cases did not appear to differ in magnitude from naturally occurring injuries or scars. Mares treated with one formulation of GnRH-KHL vaccine developed pyogenic abscesses (Goodloe, 1991). Miller et al. (2008) noted that the water and oil emulsion in GonaCon can often cause cysts, granulomas, or sterile abscesses at injection sites; in some cases, a sterile abscess may develop into a draining abscess. In elk treated with GonaCon, Powers et al. (2011) noted up to 35% of treated elk had an abscess form, despite the injection sites first being clipped and swabbed with alcohol. Even in studies where swelling and visible abscesses followed GonaCon immunization, the longer-term nodules observed did not appear to change any animal's range of movement or locomotor patterns (Powers et al., 2011; Baker et al., 2017, 2018). The result that other formulations of anti-GnRH vaccine may be associated with less notable injection site reactions in horses may indicate that the adjuvant formulation in GonaCon leads a single dose to cause a stronger immune reaction than the adjuvants used in other anti-GnRH vaccines. Despite that, a booster dose of GonaCon-Equine appears to be more effective than a primer dose alone (Baker et al., 2017). Horses injected in the hip with Improvac showed only transient reactions that disappeared within 6 days in one study (Botha et al., 2008), but stiffness and swelling that lasted 5 days were noted in another study where horses received Improvac in the neck (Imboden et al., 2006). Equity led to transient reactions that resolved within a week in some treated animals (Elhay et al., 2007). Donovan et al. (2013) noted no reactions to the canine anti-GnRH vaccine. In cows treated with Bopriva there was a mildly elevated body temperature and mild swelling at injection sites that subsided within 2 weeks (Balet et al., 2014).

Indirect Effects: PZP Vaccines

One expected long-term, indirect effect on wild horses treated with fertility control would be an improvement in their overall health (Turner & Kirkpatrick, 2002). Many treated mares would not experience the biological stress of reproduction, foaling and lactation as frequently as untreated mares. The observable measure of improved health is higher body condition scores (Nuñez et al., 2010). After a treated mare returns to fertility, that mare's future foals would be expected to be healthier overall and would benefit from improved nutritional quality in the mare's milk. This is particularly to be expected if there is an improvement in rangeland forage quality at the same time, due to reduced wild horse population size. Past application of fertility control has shown that mares' overall health and body condition remains improved even after fertility resumes. PZP treatment may increase mare survival rates, leading to longer potential lifespan (Turner & Kirkpatrick, 2002; Ransom et al., 2014a) that may be as much as 5-10 years (NPS, 2008). To the extent that this happens, changes in lifespan and decreased foaling rates could combine to cause changes in overall age structure in a treated herd (Turner & Kirkpatrick, 2002; Roelle et al., 2010), with a greater prevalence of older mares in the herd (Gross, 2000; NPS, 2008). Observations of mares treated in past gathers showed that many of the treated mares were larger than, maintained higher body condition than, and had larger healthy foals than untreated mares (BLM, anecdotal observations).

Following resumption of fertility, the proportion of mares that conceive and foal could be increased due to their increased fitness; this has been called a 'rebound effect.' Elevated fertility rates have been observed after horse gathers and removals (Kirkpatrick & Turner, 1991). If repeated contraceptive treatment leads to a prolonged contraceptive effect, then that may minimize or delay the hypothesized rebound effect. Selectively applying contraception to older animals and returning them to the range could reduce long-term holding costs for such horses, which are difficult to adopt, and may reduce the compensatory reproduction that often follows removals (Kirkpatrick & Turner, 1991).

Because successful fertility control in a given herd reduces foaling rates and population growth rates, another indirect effect should be to reduce the number of wild horses that have to be removed over time to achieve and maintain the established AML. Contraception may change a herd's age structure, with a relative increase in the fraction of older animals in the herd (NPS, 2008). Reducing the numbers of wild horses that would have to be removed in future gathers could allow for removal of younger, more easily adoptable excess wild horses, and thereby could eliminate the need to send additional excess horses from this area to off-range holding corrals or pastures for long-term holding.

A principal motivation for use of contraceptive vaccines or sex ratio manipulation is to reduce population growth rates and maintain herd sizes at AML. Where successful, this should allow for continued and increased environmental improvements to range conditions within the project area, which would have long-term benefits to wild horse and burro habitat quality, and well-being of animals living on the range. As the population nears or is maintained at the level necessary to achieve a thriving natural ecological balance, vegetation resources would be expected to recover, improving the forage available. With rangeland conditions more closely approaching a thriving natural ecological balance, and with a less concentrated distribution of wild horses and burros, there should also be less trailing and concentrated use of water sources. Lower population density should lead to reduced competition among wild horses using the water sources, and less fighting among horses accessing water sources. Water quality and quantity would continue to improve to the benefit of all rangeland users including wild horses. Wild horses would also have to travel less distance back and forth between water and desirable foraging areas. Among mares in the herd that remain fertile, a higher level of physical health and future reproductive success would be expected in areas where lower horse and burro population sizes lead to increases in water and forage resources. While it is conceivable that widespread and continued treatment with fertility control vaccines could reduce the birth rates of the population to such a point that birth is consistently below mortality, that outcome is not likely unless a very high fraction of the mares present are all treated in almost every year.

Indirect Effects: GnRH Vaccines
As noted above to PZP vaccines, an expected long-term, indirect effect on wild horses treated with fertility control would be an improvement in their overall health. Body condition of anti-GnRH-treated females was equal to or better than that of control females in published studies. Ransom et al. (2014b) observed no difference in mean body condition between GonaCon-B treated mares and controls. Goodloe (1991) found that GnRH-KHL treated mares had higher survival rates than untreated controls. Baker et al. (2023) noted higher body condition scores in GonaCon-Equine vaccine treated mares than in untreated mares. In other species, treated deer had better body condition than controls (Gionfriddo et al., 2011b), treated cats gained more weight than controls (Levy et al., 2011), as did treated young female pigs (Bohrer et al., 2014).

Following resumption of fertility, the proportion of mares that conceive and foal could be increased due to their increased fitness; this has been called by some a ‘rebound effect.’ Elevated fertility rates have been observed after horse gathers and removals (Kirkpatrick & Turner, 1991). If repeated contraceptive treatment leads to a prolonged contraceptive effect, then that may minimize or delay the hypothesized rebound effect. Selectively applying contraception to older animals and returning them to the range could reduce long-term holding costs for such horses, which are difficult to adopt, and could negate the compensatory reproduction that can follow removals (Kirkpatrick & Turner, 1991).

Because successful fertility control would reduce foaling rates and population growth rates, another indirect effect would be to reduce the number of wild horses that have to be removed over time to achieve and maintain the established AML. Contraception would be expected to lead to a relative increase in the fraction of older animals in the herd. Reducing the numbers of wild horses that would have to be removed in future gathers could allow for removal of younger, more easily adoptable excess wild horses, and thereby could eliminate the need to send additional excess horses from this area to off-range holding corrals or pastures for long-term holding. Among mares in the herd that remain fertile, a high level of physical health and future reproductive success would be expected because reduced population sizes should lead to more availability of water and forage resources per capita.

Reduced population growth rates and smaller population sizes could also allow for continued and increased environmental improvements to range conditions within the project area, which would have long-term benefits to wild horse habitat quality. As the local horse abundance nears or is maintained at the level necessary to achieve a thriving natural ecological balance, vegetation resources would be expected to recover, improving the forage available to wild horses and wildlife throughout the area. With rangeland conditions more closely approaching a thriving natural ecological balance, and with a less concentrated distribution of wild horses across the range, there should also be less trailing and concentrated use of water sources. Lower population density would be expected to lead to reduced competition among wild horses using the water sources, and less fighting among horses accessing water sources. Water quality and quantity would continue to improve to the benefit of all rangeland users including wild horses. Wild horses would also have to travel less distance back and forth between water and desirable foraging areas. Should GonaCon-Equine treatment, including booster doses, continue into the future, with treatments given on a schedule to maintain a lowered level of fertility in the herd, the chronic cycle of overpopulation and large gathers and removals might no longer occur, but instead a consistent abundance of wild horses could be maintained, resulting in continued improvement of overall habitat conditions and animal health. While it is conceivable that widespread and continued treatment with GonaCon-Equine could reduce the birth rates of the population to such a point that birth is consistently below mortality, that outcome is not likely unless a very high fraction of the mares present are all treated with primer and booster doses, and perhaps repeated booster doses.

Behavioral Effects: PZP Vaccines

Behavioral difference, compared to mares that are fertile, should be considered as potential results of successful contraception. The NRC report (2013) noted that all forms of fertility suppression have effects on mare behavior, mostly because of the lack of pregnancy and foaling, and concluded that fertility control vaccines were among the most promising fertility control methods for wild horses and burros. The resulting impacts may be seen as neutral in the sense that a wide range of natural behaviors is already observable in untreated wild horses, or mildly adverse in the sense that effects are expected to be transient and to not affect all treated animals.

PZP vaccine-treated mares may continue estrus cycles throughout the breeding season. Ransom and Cade (2009) delineated wild horse behaviors. Ransom et al. (2010) found no differences in how PZP-treated and untreated mares allocated their time between feeding, resting, travel, maintenance, and most social behaviors in three populations of wild horses, which is consistent with Powell's (1999) findings in another population. Likewise, body condition of PZP-treated and control mares did not differ between treatment groups in Ransom et al.'s (2010) study. Nuñez et al. (2010) found that PZP-treated mares had higher body condition than control mares in another population, presumably because energy expenditure was reduced by the absence of pregnancy and lactation. Knight (2014) found that PZP-treated mares had better body condition, lived longer and switched harems more frequently, while mares that foaled spent more time concentrating on grazing and lactation and had lower overall body condition.

In two studies involving a total of four wild horse populations, both Nuñez et al. (2009) and Ransom et al. (2010) found that PZP vaccine treated mares were involved in reproductive interactions with stallions more often than control mares, which is not surprising given the evidence that PZP-treated females of other mammal species can regularly demonstrate estrus behavior while contracepted (Shumake and Killian 1997, Heilmann et al. 1998, Curtis et al. 2002, Duncan et al. 2017). There was no evidence, though, that mare welfare was affected by the increased level of herding by stallions noted in Ransom et al. (2010). Later analysis by Nuñez et al. (2017) noted no difference in mare reproductive behavior as a function of contraception history.

Ransom et al. (2010) found that control mares were herded by stallions more frequently than PZP-treated mares, and Nuñez et al. (2009, 2014, 2017, 2018) found that PZP-treated mares exhibited higher infidelity to their band stallion during the non-breeding season than control mares. Madosky et al. (2010) and Knight (2014) found this infidelity was also evident during the breeding season in the same population that Nuñez et al. (2009, 2010, 2014, 2017, 2018) studied. Nuñez et al. (2014, 2017) and Nuñez (2018) concluded that PZP-treated mares changing bands more frequently than control mares could lead to band instability. Nuñez et al. (2009), though, cautioned against generalizing from that island population to other herds. Also, despite any potential changes in band infidelity due to PZP vaccination, horses continued to live in social groups with dominant stallions and one or more mares. Nuñez et al. (2014) found elevated levels of fecal cortisol, a marker of physiological stress, in mares that changed bands. The research is inconclusive as to whether all the mares' movements between bands were related to the PZP treatments themselves or the fact that the mares were not nursing a foal and did not demonstrate any long-term negative consequence of the transiently elevated cortisol levels. In separate work in a long-term study of semi-feral Konik ponies, Jaworska et al. (2020) showed that neither infanticide nor feticide resulted for mares and their foals after a change in dominant stallion. Nuñez et al. (2014) wrote that these effects "…may be of limited concern when population reduction is an urgent priority." Nuñez (2018) and Jones et al. (2019, 2020) noted that band stallions of mares that have received PZP treatment can exhibit changes in behavior and physiology. Nuñez (2018) cautioned that PZP use may limit the ability of mares to return to fertility, but also noted that, "such aggressive treatments may be necessary when rapid reductions in animal numbers are of paramount importance…If the primary management goal is to reduce population size, it is unlikely (and perhaps less important) that managers achieve a balance between population control and the maintenance of more typical feral horse behavior and physiology."

In contrast to transient stresses, Creel et al. (2013) highlight that variation in population density is one of the most well-established causal factors of chronic activation of the hypothalamic-pituitary-adrenal axis, which mediates stress hormones; high population densities and competition for resources can cause chronic stress. Creel et al. (2013) also states that "…there is little consistent evidence for a negative association between elevated baseline glucocorticoids and fitness." Band fidelity is not an aspect of wild horse biology that is specifically protected by the WFRHBA of

1971. It is also notable that Ransom et al. (2014b) found higher group fidelity after a herd had been gathered and treated with a contraceptive vaccine; in that case, the researchers postulated that higher fidelity may have been facilitated by the decreased competition for forage after excess horses were removed. At the population level, available research does not provide evidence of the loss of harem structure among any herds treated with PZP. No biologically significant negative impacts on the overall animals or populations overall, long-term welfare or well-being have been established in these studies.

The National Research Council (2013) found that harem changing was not likely to result in serious adverse effects for treated mares: "The studies on Shackleford Banks (Nuñez et al., 2009; Madosky et al., 2010) suggest that there is an interaction between pregnancy and social cohesion. The importance of harem stability to mare well-being is not clear but considering the relatively large number of free-ranging mares that have been treated with liquid PZP in a variety of ecological settings, the likelihood of serious adverse effects seem low."

Nuñez et al. (2010) stated that not all populations would respond similarly to PZP treatment. Differences in habitat, resource availability, and demography among conspecific populations would undoubtedly affect their physiological and behavioral responses to PZP contraception and may be considered. Kirkpatrick et al. (2010) concluded that: "the larger question is, even if subtle alterations in behavior may occur, this is still far better than the alternative," and that the "…other victory for horses is that every mare prevented from being removed, by virtue of contraception, is a mare that would only be delaying her reproduction rather than being eliminated permanently from the range. This preserves herd genetics, while gathers and adoption do not."

The NRC report (2013) provides a comprehensive review of the literature on the behavioral effects of contraception that puts research up to that date by Nuñez et al. (2009, 2010) into the broader context of all of the available scientific literature, and cautions, based on its extensive review of the literature that: ". . . in no case can the committee conclude from the published research that the behavior differences observed are due to a particular compound rather than to the fact that treated animals had no offspring during the study. That must be borne in mind particularly in interpreting long-term impacts of contraception (e.g., repeated years of reproductive "failure" due to contraception)."

Behavioral Effects: GnRH Vaccines

The result that GonaCon treated mares may have suppressed estrous cycles throughout the breeding season can lead treated mares to behave in ways that are functionally similar to pregnant mares. Where it is successful in mares, GonaCon and other anti-GnRH vaccines are expected to induce fewer estrous cycles when compared to non-pregnant control mares. This has been observed in many studies (Garza et al., 1986; Curtis et al., 2002; Dalin et al., 2002; Killian et al., 2006; Dalmau et al., 2015). Females treated with GonaCon had fewer estrous cycles than control or PZP-treated mares (Killian et al., 2006) or deer (Curtis et al., 2002). Thus, any concerns about PZP treated mares receiving more courting and breeding behaviors from stallions (Nuñez et al., 2009; Ransom et al., 2010) are not generally expected to be a concern for mares treated with anti-GnRH vaccines (Botha et al., 2008).

Ransom et al. (2014b) and Baker et al. (2018) found that GonaCon treated mares had similar rates of reproductive behaviors that were similar to those of pregnant mares. Among other potential causes, the reduction in progesterone levels in treated females may lead to a reduction in behaviors associated with reproduction. Despite this, some females treated with GonaCon, or other anti-GnRH vaccines, did continue to exhibit reproductive behaviors, albeit at irregular intervals and durations (Dalin et al., 2002; Stout et al., 2003; Imboden et al., 2006), which is a result that is similar to spayed (ovariectomized) mares (Asa et al., 1980). Gray (2009) and Baker et al. (2018) found no difference in sexual behaviors in mares treated with GonaCon and untreated mares. In a sense, the hormonal state of and the behaviors of GonaCon-Equine vaccine treated animals is generally comparable to when they are pregnant, but Baker et al. (2023) noted that GonaCon-Equine treated mares actually do still "…show periodic estrous behaviors throughout the normal breeding season suggesting that vaccination only partially suppresses the hormones responsible for stimulating reproductive behavior, although concentrations are likely insufficient to induce ovulation." Mares treated with GonaCon-Equine do not leave their bands any more often than untreated mares. In fact, Ransom et al. (2014b) actually found increased levels of band fidelity after treatment with GonaCon-Equine. Baker et al. (2018) reported that GonaCon-Equine treated mares received slightly more harem-social behaviors from stallions than untreated mares, but that most of those social behaviors were allo-grooming. When progesterone levels are low, small changes in estradiol concentration can foster reproductive estrous behaviors (Imboden et al., 2006). Owners of anti-GnRH vaccine treated mares reported a reduced number of estrous-related behaviors under saddle (Donovan et al., 2013). Treated mares may refrain from reproductive behavior even after ovaries return to cyclicity (Elhay et al., 2007). Studies in elk found that GonaCon treated cows had equal levels of precopulatory behaviors as controls (Powers et al., 2011), though bull elk paid more attention to treated cows late in the breeding season, after control cows were already pregnant (Powers et al., 2011).

Stallion herding of mares, and harem switching by mares are two behaviors related to reproduction that might change as a result of contraception. Ransom et al. (2014b) observed a 50% decrease in herding behavior by stallions after the free-roaming horse population at Theodore Roosevelt National Park was reduced via a gather, and mares there were treated with GonaCon-B. The increased harem tending behaviors by stallions were directed to both treated and control mores. It is difficult to separate any effect of GonaCon in this study from changes in horse density and forage following horse removals.

With respect to treatment with GonaCon or other anti-GnRH vaccines, it is probably less likely that treated mares would switch harems at higher rates than untreated animals, because treated mares are similar to pregnant mares in their behaviors (Ransom et al., 2014b). Indeed, Gray (2009) found no difference in band fidelity in a free-roaming population of horses with GonaCon treated mares, despite differences in foal production between treated and untreated mares. Ransom et al. (2014b) actually found increased levels of band fidelity after treatment, though this may have been partially a result of changes in overall horse density and forage availability.

Gray (2009) and Ransom et al. (2014b) monitored non-reproductive behaviors in GonaCon treated populations of free-roaming horses. Gray (2009) found no difference between treated and untreated mares in terms of activity budget, sexual behavior, proximity of mares to stallions, or aggression. Ransom et al. (2014b) found only minimal differences between treated and untreated mare time budgets, but those differences were consistent with differences in the metabolic demands of pregnancy and lactation in untreated mares, as opposed to non-pregnant treated mares.

Genetic Effects of Fertility Control Vaccines

In HMAs where large numbers of wild horses have recent and / or an ongoing influx of breeding animals from other areas with wild or feral horses, contraception is not expected to cause an unacceptable loss of genetic diversity or an unacceptable increase in the inbreeding coefficient. In any diploid population, the loss of genetic diversity through inbreeding or drift can be prevented by large effective breeding population sizes (Wright, 1931) or by introducing new potential breeding animals (Mills & Allendorf, 1996). The NRC report (2013) recommended that single HMAs should not be considered as isolated genetic populations. Rather, managed herds of wild horses should be considered as components of interacting metapopulations, with the potential for interchange of individuals and genes taking place as a result of both natural and human-facilitated movements. Introducing 1-2 mares every generation (about every 10 years) is a standard management technique that can alleviated potential inbreeding concerns (BLM, 2010).

In the last 10 years, there has been a high realized growth rate of wild horses in most areas administered by the BLM, such that most alleles that are present in any given mare are likely to already be well represented in that mare’s siblings, cousins, and more distant relatives. With the exception of horses in a small number of well-known HMAs that contain a relatively high fraction of alleles associated with old Spanish horse breeds (NRC, 2013), the genetic composition of wild horses in lands administered by the BLM is consistent with admixtures from domestic breeds. As a result, in most HMAs, applying fertility control to a subset of mares is not expected to cause irreparable loss of genetic diversity. Improved longevity and an aging population are expected results of contraceptive treatment that can provide for lengthening generation time; this result would be expected to slow the rate of genetic diversity loss (Hailer et al., 2006). In a relatively small population with empirically documented individual genotypes, Zimmerman et al. (2023) used projections to determine that adequate genetic diversity should be maintained despite immunocontraception and planned periodic gathers. Based on a population model, Gross (2000) found that a strategy to preferentially treat young animals with a contraceptive led to more genetic diversity being retained than either a strategy that preferentially treats older animals, or a strategy with periodic gathers and removals.

Even if it is the case that repeated treatment with a fertility control vaccine may lead to prolonged infertility, or even sterility in some mares, most HMAs have only a low risk of loss of genetic diversity if logistically realistic rates of contraception are applied to mares. Wild horses in most herd management areas are descendants of a diverse range of ancestors coming from many breeds of domestic horses. As such, the existing genetic diversity in the majority of HMAs does not contain unique or historically unusual genetic markers. Past interchange between HMAs, either through natural dispersal or through assisted migration (i.e., human movement of horses) means that many HMAs are effectively indistinguishable and interchangeable in terms of their genetic composition (i.e., see the table of Fst vales *in* NRC, 2013). Roelle and Oyler-McCance (2015) used the VORTEX population model to simulate how different rates of mare sterility would influence population persistence and genetic diversity, in populations with high or low starting levels of genetic diversity, various starting population sizes, and various annual population growth rates. Their results show that the risk of the loss of genetic heterozygosity is extremely low except in case where all of the following conditions are met: starting levels of genetic diversity are low, initial population size is 100 or less, the intrinsic population growth rate is low (5% per year), and very large fractions of the female population are permanently sterilized.

It is worth noting that, although maintenance of genetic diversity at the scale of the overall population of wild horses is an intuitive management goal, there are no existing laws or policies that require BLM to maintain genetic diversity at the scale of the individual herd management area or complex. Also, there is no Bureau-wide policy that requires BLM to allow each female in a herd to reproduce before treatment with contraceptives.

Fertility Control Vaccines and the Evolution of Immune Response

One concern that has been raised with regards to genetic diversity is that treatment with immunocontraceptives could possibly lead to an evolutionary increase in the frequency of individuals whose genetic composition fosters weak immune responses (Cooper & Larson, 2006; Ransom et al., 2014a). Based on principles of population genetics, likely application rates in wild horse and burro metapopulations, and on currently available knowledge, it appears unlikely that BLM's application of fertility control vaccines would cause biologically significant, population-level evolutionary changes in the capacity to mount healthy immune responses, for reasons noted below.

In well-monitored wild horse herds that have been treated with PZP vaccine for many years, there have been a small number of mares that are 'non-responders' – that is, they continue to be fertile despite multiple treatments with ZonaStat-H PZP vaccine (BLM, 2023). To the extent that this outcome may be partly attributable to genes, then for such 'non-responder' genes to spread widely in the population, both heritability and the selection coefficient must be high. Many factors influence the strength of a vaccinated individual's immune response, potentially including genetics, but also nutrition, body condition, and prior immune responses to pathogens or other antigens (Powers et al., 2011). The premise of the concern (Cooper & Larson, 2006; Ransom et al., 2014a) is based on an assumption that lack of immune response to any given fertility control vaccine is a highly heritable trait, that the great majority of mares in a population would be treated with immunocontraceptives, that treated 'non-responder' mares would give birth to a far greater number of foals than other treated mares, and that the result would be an increasing frequency of the poor immune response associated trait over time in a population of vaccine-treated animals. Cooper and Herbert (2001) reviewed the topic, in the context of concerns about the long-term effectiveness of immunocontraceptives as a control agent for exotic eutherian species in Australia. They argue that imunocontraception could be a strong selective pressure, and that selecting for reproduction in individuals with poor immune response could lead to a general decline in immune function in populations where such evolution takes place. Other authors have also speculated that differences in antibody titer responses could be partially due to genetic differences between animals (Curtis et al., 2002; Herbert & Trigg, 2005). However, Magiafoglou et al. (2003) clarify that if the variation in immune response is due to environmental factors (i.e., body condition, social rank) and not due to genetic factors, then there would be no expected effect of the immune phenotype on future generations. It is possible that general health, as measured by body condition, can have a causal role in determining immune response, with animals in poor condition demonstrating poor immune reactions (NRC, 2013).

Correlations between physical factors and immune response would not preclude, though, that there could also be a heritable response to immunocontraception. In studies not directly related to immunocontraception, immune response has been shown to be heritable (Kean et al., 1994; Sarker et al., 1999). Predictions about the long-term, population-level evolutionary response to immunocontraceptive treatments have been largely speculative up to this point, with outcomes likely to depend on several factors, including: the strength of the genetic predisposition to not respond to the fertility control vaccine; the heritability of that gene or genes; the initial prevalence of that gene or genes; the number of mares treated with a primer dose of the vaccine (which generally has a short-acting effect); the number of mares treated with one or more booster doses of the vaccine; and the actual size of the genetically-interacting metapopulation of horses within which the vaccine treatment takes place.

One recent study attempted to quantify the heritability of a decreased response to fertility control vaccine-induced duration of infertility and the pattern of single nucleotide polymorphisms (SNPs) in the genomes of feral mares in Theodore Roosevelt National Park. SNPs can be associated with DNA variants in nearby coding regions, due to linkage. 53 mares were treated with the GonaCon-Equine immunocontraception vaccine, and 25 were not. Almost all of the GonaCon treated mares became infertile for at least one year. The researchers found a correlation between a more rapid return to fertility and several SNPs. The SNPs that were correlated with a more rapid return to fertility are not known to be located in coding regions of genes that influence immune response, but based on the location of those SNPs the researchers suggested that there may be an association with genes that may influence immune response. The researchers estimated that the heritability for genetic effects on the duration of GonaCon effectiveness in feral horse mares was $h^2 = 0.27$ (SE = 0.23). They characterized this level of heritability as 'moderate.' There are several reasons to expect that in any single managed herd of wild horses, there would be the potential for only a relatively low strength of selection promoting the genes identified in the paper. Almost all of those treated mares became infertile for some time, even though certain SNPs were correlated with a marginally faster return to fertility. The fact that immunocontraception with GonaCon still reduced fertility in treated mares is indicative of a weaker selection potential than if treated mares with those SNPs had remained entirely fertile. These reasons include the only 'moderate' levels of heritability identified by Thompson et al. (2022), the expectation that mares treated multiple times should experience additional duration of effect after each dose, the likelihood that an essentially random selection of mares in the herd would not be treated at all with an immunocontraceptive, the possible non-genetic causes that treated mares may return to fertility, and the large genetic effective population size of wild horse metapopulations that is characterized across multiple HMAs and complexes. The results from Thompson et al. (2022) would not be expected substantively to change expectations about the effects of potentially heritable immune responses to immunocontraceptive vaccines. Thompson et al. (2022) based their results on mares that were treated twice with GonaCon-Equine. While some treated mares may carry genes that marginally decrease vaccine effectiveness and cause them to return to fertility faster, there may also be other treated mares who do not carry those genes but experience poor vaccine due to environmental or other causes. Of course, any mares that are not treated with immunocontraceptives would be expected to contribute more foals to the herd than treated mares, and the choice of which mares happen to be treated or not be treated would be essentially random with respect to the SNPs identified. In their conclusions, Thompson et al. (2022) suggest that wild horse managers should not rely solely on immunocontraceptive methods for herd management; in the three HMAs under consideration in this EA, gathers and immunocontraception are both considered for use in the Proposed Action. Therefore, the continued presence of untreated and other reproducing mares is likely to reduce any risk of long-term evolutionary reduction in immune function in these herds.

Although a few, generally isolated, feral horse populations have been treated with high fractions of mares receiving PZP immunocontraception for long-term population control (e.g., Assateague Island National Park, and Pryor Mountains Herd Management Area), the BLM is unaware of any studies that tested for changes in immune competence in those areas.

Sex Ratio Manipulation

Skewing the sex ratio of a herd so that there are more males than females is an established BLM management technique for reducing population growth rates. As part of a wild horse and burro gather process, the number of animals returned to the range may include more males, the number removed from the range may include more females, or both. By reducing the proportion of breeding females in a population (as a fraction of the total number of animals present), the technique leads to fewer foals being born, relative to the total herd size.

Sex ratio can vary in local populations of wild horses, with many having approximately equal numbers of males and females, some having more females, and some more males. Basic principles of wildlife demography posit that for populations where there is no major influence of any sex-biased immigration or emigration, the realized sex ratio is expected to be a result of sex ratios at birth and sex-specific survival rates at different ages.

Across many herds of federally managed wild horses and feral horses, there can be substantial variation in the sex ratio at birth. Ransom et al (2016) summarized information about sex ratio at birth across all wild equid species, in a meta-analysis of demographic studies that were available up to that time. Across all wild equid species, Ransom et al. (2016) documented a sex ratio at birth that was slightly skewed toward males on average, with 1.1 male foal born for every 1 female foal. However, the 95% confidence interval for that ratio across wild equid populations was from 0.93:1 to 1.29:1. The actual value of sex ratio at birth can vary from herd to herd and over time and appears to be influenced by environmental conditions. Ransom et al. (2016) cited studies indicating that female equids tend to give birth to female foals at higher rates when they are living in conditions with inadequate natural resources, when they are in relatively poorer body condition (Cameron et al., 1999), or when they give birth for the first time at very young ages. When free-roaming mares were experiencing improving body condition, they tended to give birth to male foals at high rates (Cameron & Linklater, 2007), consistent with predictions of the Trivers-Willard hypothesis that mares in better condition would tend to invest more effort into the sex with higher variance in reproductive success.

The following is not an exhaustive review of all available studies that document adult sex ratio in wild or free-roaming horses, but a conclusion that can be drawn from across many studies is that there is a range of observed sex ratios; there is no single typical sex ratio typical in either unmanaged or managed herds. In a comprehensive 1973-1987 study of 74 management areas that did not have any fertility control applications, Garrott (1991) documented that over half had male to female ratios that were very close to 50:50 (not statistically different from equal numbers of males and females). Among the others, many herds did have more females than males. Over 84% of those areas had male to female parity in horses under 1 year old (Garrott, 1991). Survival of foals appears to be, on average, equal between male and female foals. In herds without fertility control, Garrott (1991) concluded that young adult male horses had lower survival than young female horses, but that older adult male horses had higher survival than older adult female horses.

The realized overall sex ratio in any given wild horse or burro herd would also be influenced by age-specific and sex-specific survival rates. Mare fertility control application in wild horses increases adult mare survival (Turner & Kirkpatrick, 2002; Ransom et al., 2014a). This is expected cause an increase in adult females over time in a herd that has been treated with mare fertility control. During 1993-2007, wild horses in the Pryor Mountains were studied intensively; during that time adult sex ratio varied in the range from 44% to 55% male. The contemporary Pryor Mountain herd sex ratio is an example of where long use of fertility control vaccine has likely affected the sex ratio, which is ~57% female. However, this is largely driven by high mare longevity in the 20+ year-old age class (20 mares vs. only 2 studs), that is most likely caused by those mares having relatively few foals. Discounting that age class, the sex ratio at Pryor Mountains herd is ~52% female (BLM, 2023). Before helicopter gathers or fertility control treatments began at Sheldon national wildlife refuge, the sex ratio of adults (3 years old or older) was 55% male (424 stallions to 353 mares; Collins & Kasbahm, 2016). On an Atlantic barrier island in Georgia, Goodloe et al (2000) documented overall adult sex ratio that was 62% male. On Sable Island (Canada) where resources are limited and there is relatively high post-natal mare mortality, sex ratios have been over 60% male (Regan et al., 2020).

In BLM management actions that include it, sex ratio is typically adjusted so that up to 60% of the horses are male. In the absence of other fertility control treatments, this 60:40 sex ratio can temporarily reduce population growth rates from approximately 20% to approximately 15% (Bartholow, 2004). While such a decrease in growth rate may not appear to be large or long-lasting, the net result can be that fewer foals being born, at least for a few years – this can extend the time between gathers, and reduce impacts on-range, and costs off-range. Any impacts of sex ratio manipulation are expected to be temporary because the sex ratio of wild horse and burro foals at birth is approximately equal between males and females (NRC, 2013), and it is common for female foals to reproduce by their second year (NRC, 2013). Thus, within a few years after a gather and selective removal that leads to more males than females, the sex ratio of reproducing wild horses and burros would be returning toward a 50:50 ratio.

Having a larger number of males than females is expected to lead to several demographic and behavioral changes as noted in the NRC report (2013), including the following. Having more fertile males than females should not alter the fecundity of individual fertile females. Wild mares may be distributed in a larger number of smaller harems (Regan et al., 2020). Singer and Schoeneker (2000) found that increases in the number of males on Pryor Mountain Wild Horse

Range herd management area lowered the breeding male age but did not alter the birth rate among females. If females are distributed among a larger number of smaller harems, it is expected that genetic effective population size (Ne) should increase relative to a herd of the same number of mares, but with 50:50 sex ratio. Competition and aggression between males may cause a decline in male body condition. Female foraging may be somewhat disrupted by elevated male-male aggression. With a greater number of males available to choose from, females may have opportunities to select more genetically fit sires. There would also be an increase the genetic effective population size because more stallions would be breeding and existing females would be distributed among many more small harems. This last beneficial impact is one reason that skewing the sex ratio to favor males is listed in the BLM wild horse and burro handbook (BLM 2010) as a method to consider in herds where there may be concern about the loss of genetic diversity; having more males fosters a greater retention of genetic diversity.

Changes in which stallions mate with mares are a natural part of the wild horse behavioral repertoire. Berger (1983) reported forced copulations after band stallion changes, but these were not related to sex ratio per se, considering that the sex ratio in the populations he studied were approximately 43% male (Grange et al 2009). Kirkpatrick and Turner (1991) looked for but did not find any forced copulation or induced abortions after stallion changes in wild horse bands. Infanticide is a natural behavior that has been observed in wild equids (Feh and Munkhtuya 2008, Gray 2009), but there are no published accounts of infanticide rates increasing as a result of having a skewed sex ratio in wild horse or wild burro herds. Any comment that implies such an impact would be speculative.

The BLM wild horse and burro management handbook (BLM 2010) discusses this method. The handbook acknowledges that there may be some behavioral impacts of having more males than females. The handbook includes guidelines for when the method should be applied, specifying that this method should be considered where the low end of the AML is 150 animals or greater, and with the result that males comprise 60–70% of the herd. Having more than 70% males may result in unacceptable impacts in terms of elevated male-male aggression. In NEPA analyses, BLM has chosen to follow these guidelines in some cases, for example:

- In the 2015 Cold Springs HMA Population Management Plan EA (DOI-BLM-V040-2015-022), the low end of AML was 75. Under the preferred alternative, 37 mares and 38 stallions would remain on the HMA. This is well below the 150 head threshold noted above.
- In the 2017 Hog Creek HMA Population Management Plan EA (DOI-BLM-ORWA-V000-2017-0026-EA), BLM clearly identified that maintaining a 50:50 sex ratio was appropriate because the herd size at the low end of AML was only 30 animals.

It is relatively straightforward to speed the return of skewed sex ratios back to a 50:50 ratio. The BLM wild horse and burro handbook (BLM 2010) specifies that, if post-treatment monitoring reveals negative impacts to breeding harems due to sex ratio manipulation, then mitigation measures could include removing males, not introducing additional males, or releasing a larger proportion of females during the next gather.

<u>**References: Fertility Control Vaccines**</u>

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Effects of Female Sterilization and Male Neutering

Various forms of fertility control can be used in wild horses and wild burros, with the goals of maintaining herds at or near AML, reducing fertility rates, and reducing the frequency of gathers and removals. The WFRHBA of 1971 specifically provides for contraception and sterilization (16 U.S.C. 1333 section 3.b.1). Fertility control measures have been shown to be a cost-effective and humane treatment to slow increases in wild horse populations or, when used in combination with gathers, to reduce horse population size (Bartholow, 2004; de Seve & Boyles-Griffin, 2013; Fonner & Bohara, 2017). Population growth suppression becomes less expensive if fertility control is long-lasting (Hobbs et al., 2000), such as with sterilization methods. Sterilizing a female horse (mare) or burro (jenny) can be accomplished by several methods, some of which are minimally invasive, and others of which are surgical. In this review, 'spaying' is defined to be surgical sterilization, usually accomplished by removal of the ovaries, but other surgical methods such as tubal ligation that lead to sterility may also be considered by some to be a form of spaying. Minimally invasive, physical forms of sterilization, such as trans-cervical methods that occlude the oviduct, are not labeled as spaying in this review, but may have similar physiological outcomes as surgical methods that leave the ovaries intact. In this review, 'neutering' is defined to be the sterilization of a male horse (stallion) or burro (jack), either by removal of the testicles (castration, also known as gelding) or by vasectomy, where the testicles are retained but no sperm leave the body by severing or blocking the vas deferens or epididymis.

In the context of BLM wild horse and burro management, sterilization is expected to be successful to the extent that it reduces the number of reproducing females. By definition, sterilizing a given female is 100% effective as a fertility control method for that female. Neutering males may be effective in one of two ways. First, neutered males may continue to guard fertile females, preventing the females from breeding with fertile males. Second, if neutered males are included in a herd that has a high male-to-female sex ratio, then the neutered males may comprise some of the animals within the appropriate management level (AML) of that herd, which would effectively reduce the number of females in the herd. Although these and other fertility control treatments may be associated with a number of potential physiological, behavioral, demographic, and genetic effects, those impacts are generally minor and transient, do not prevent overall maintenance of a self-sustaining population, and do not generally outweigh the potential benefits of using contraceptive treatments in situations where it is a management goal to reduce population growth rates (Garrott & Oli, 2013).

Peer-reviewed scientific literature details the expected impacts of sterilization methods on wild horses and burros. No finding of excess animals is required for BLM to pursue sterilization in wild horses or wild burros, but NEPA analysis has been required. This review focuses on peer-reviewed scientific literature. The summary that follows first examines effects of female sterilization, then neuter use in males. This review does not examine effects of fertility control vaccines. Cited studies are generally limited to those involving horses and burros, except where including studies on other species helps in making inferences about physiological or behavioral questions not exhaustively addressed in horses or burros specifically. While there are notable differences between the species in their anatomy, diet, behaviors, and metabolism (Burden & Thiemann, 2015), the essential endocrine controls of the hypothalamic-pituitary-gonadal axis and the function of the zona pellucida in fertility are the same. While most studies reviewed are based on results from horses, burros are similar enough in their reproductive physiology and immunology (Turini et al., 2021) that expected effects of immunocontraception are comparable.

On the whole, the identified impacts at the herd level are generally transient. The principle impact to individuals treated is sterility, which is the intended outcome. Sterilization that affects individual horses and burros does not prevent BLM from ensuring that there would be self-sustaining populations of wild horses and burros in single HMAs, in complexes of HMAs, and at regional scales of multiple HMAs and complexes. Under the WFRHBA of 1971, BLM is charged with maintaining self-reproducing populations of wild horses and burros. The WFRHBA makes clear that BLM is not explicitly charged with ensuring the fertility of any given individual wild horse or burro. The National Research Council of the National Academies of Sciences (2013) encouraged BLM to manage wild horses and burros at the spatial scale of "metapopulations" – that is, across multiple HMAs and complexes in a region. In fact, many HMAs have historical and ongoing genetic and demographic connections with other HMAs, and BLM routinely moves animals from one to another to improve local herd traits and maintain high genetic diversity.

Discussions about herds that include some 'non-reproducing' individuals, or even those that are entirely non-reproducing, should be considered in the context of this 'metapopulation' structure, where the 'self-sustaining' nature of herds is not necessarily to be measured at the scale of single HMAs. So long as the definition of what constitutes a self-sustaining herd includes the larger set of HMAs that have past or ongoing demographic and genetic connections – as is recommended by the NRC 2013 report – it is clear that particular HMAs can be managed as non-reproducing in whole or in part while still allowing for a self-sustaining population of wild horses or burros at the broader spatial scale. Wild horses are not an endangered species (USFWS, 2015), nor are they rare. Over 64,000 adult wild horses and over 17,000 adult wild burros roamed BLM lands as of March 1, 2022, and those numbers do not include at least 9,000 WHB on US Forest Service lands, nor at least 100,000 feral horses on tribal lands in the Western United States (Schoenecker et al., 2021).

All fertility control methods affect the behavior and physiology of treated animals (NRC, 2013), and are associated with potential risks and benefits, including effects of handling, frequency of handling, physiological effects, behavioral effects, and reduced population growth rates (Hampton et al., 2015). Contraception methods alone do not remove excess horses from an HMA's population, so one or more gathers are usually needed in order to bring the herd down to a level close to AML. Horses are long-lived, potentially reaching 20 years of age or more in the wild. Except in cases where extremely high fractions of mares are rendered infertile over long time periods of (i.e., 10 or more years), spaying and neutering are not very effective at reducing population growth rates to the point where births equal deaths in a herd. However, even modest levels of fertility control activities can reduce the frequency of horse gather activities, and costs to taxpayers. Population growth suppression becomes less expensive if fertility control is long-lasting (Hobbs et al., 2000), such as with sterilization. Because sterilizing animals requires capturing and handling, the risks and costs associated with capture and handling of horses may be comparable to those of gathering for removal, but with expectedly lower adoption and long-term holding costs.

Effects of handling and marking

Sterilization techniques, while not reversible, may control horse reproduction without the kind of additional handling or darting that can be needed to administer contraceptive vaccines. In this sense, sterilization can be used to achieve herd management objectives with a relative minimum level of animal handling and management over the long term. The WFRHBA (as amended) indicates that management should be at the minimum level necessary to achieve management objectives (CFR 4710.4), and if sterilizing mares or neutering some stallions can lead to a reduced number of handling occasions and removals of excess horses from the range, then that is consistent with legal guidelines. Other fertility control options that may be temporarily effective on male horses, such as the injection of GonaCon-Equine immunocontraceptive vaccine, apparently require multiple handling occasions to achieve longer-term male infertility. Similarly, some formulations of PZP immunocontraception that is currently available for use in female wild horses and burros require handling or darting every year (though longer-term effects may result after 4 or more treatments; Nuñez et al., 2017). By some measures, any management activities that require multiple capture operations to treat a given individual could be seen as more intrusive for wild horses and potentially less sustainable than an activity that requires only one handling occasion.

It is prudent for sterilized animals to be readily identifiable, either via freeze brand marks or unique coloration, and uniquely numbered RFID chips inserted in the nuchal ligament, so that their treatment history is easily recognized (BLM, 2010). Markings may also be useful into the future to determine the approximate fraction of geldings in a herd and could provide additional insights about gather efficiency. BLM has instituted capture and animal welfare program guidelines to reduce the sources of handling stress in captured animals (BLM, 2021). Handling may include freeze-marking, for the purpose of identifying an individual. Some level of transient stress is likely to result in newly captured horses that are not previously marked. Under past management practices, captured horses experienced increased, transient stress levels from handling (Ashley & Holcombe, 2001). It is difficult to compare that level of temporary stress with long-term stress that can result from food and water limitation on the range (Creel et al., 2013), which could occur in the absence of herd management.

Most horses recover from the stress of capture and handling quickly once released back to the range, and none are expected to suffer serious long-term effects from gelding, other than the direct consequence of becoming infertile.

Observations of the long-term outcomes of sterilization may be recorded during routine resource monitoring work. Such observations could include but not be limited to band size, social interactions with other geldings and harem bands, distribution within their habitat, forage utilization and activities around key water sources. Periodic population inventories and future gather statistics could provide additional anecdotal information.

Neutering Males

Whether or not stallion sterilization methods are considered in any of the action alternatives in this EA, they are included here for comparison and for the sake of completeness in the review. Castration (the surgical removal of the testicles, also called gelding or neutering) is a surgical procedure for the horse sterilization that has been used for millennia. Vasectomy involves severing or blocking the vas deferens or epididymis, to prevent sperm from being ejaculated. The procedures are fairly straight forward and has a relatively low complication rate. As noted in the review of scientific literature that follows, the expected effects of gelding and vasectomy are well understood overall, even though there is some degree of uncertainty about the exact quantitative outcomes for any given individual (as is true for any natural system).

Including a portion of neutered males in a herd can lead to a reduced population-level per-capita growth rate if they cause a marginal decrease in female fertility or if the neutered males take some of the places that would otherwise be occupied by fertile females. By having a skewed sex ratio with fewer females than males (fertile stallions plus neutered males), the result would be a lower number of breeding females in the population. Including neutered males in herd management is not new for BLM and federal land management. Geldings have been released on BLM lands as a part of herd management in the Barren Valley complex in Oregon (BLM, 2011), the Challis HMA in Idaho (BLM, 2012), and the Conger HMA in Utah (BLM, 2016). Vasectomized males and geldings were also included in US Fish and Wildlife Service management plans for the Sheldon National Wildlife Refuge that relied on sterilization and removals (Collins & Kasbohm, 2016). Taking into consideration the literature available at the time, the National Research Council of the National Academies of Sciences concluded in their 2013 report that a form of vasectomy was one of the three most promising methods for WH&B fertility control (NRC, 2013). However, BLM is not pursuing the chemical vasectomy method. The NRC panel noted that, even though chemical vasectomy had been used in dogs and cats up to that time, “There are no published reports on chemical vasectomy in horses...” and that, “Only surgical vasectomy has been studied in horses, so side effects of the chemical agent are unknown.” The only known use of chemical vasectomy in horses was published by Scully et al. (2015); this was part of a study cited in the EA (Collins & Kasbohm, 2016). They injected chlorhexidine into the stallions’ epididymis. That is the same chemical agent as had been used to chemically vasectomize dogs. Scully et al. (2015) found that the chemical vasectomy method failed to prevent fertile sperm from being located in the vas deferens seminal fluid. Stallions treated with the chemical vasectomy method still had viable sperm and were still potentially as fertile as untreated ‘control’ stallions in that study. Thus, the method did was not effective.

Nelson (1980) and Garrott and Siniff (1992) modeled potential efficacy of male-oriented contraception as a population management tool, and both studies agreed that while slowing growth, sterilizing only dominant males (i.e., harem-holding stallions) would result in only marginal reduction in female fertility rates. Eagle et al. (1993) and Asa (1999) tested this hypothesis on HMAs where dominant males were vasectomized. Their findings agreed with modeling results from previous studies, and they also concluded that sterilizing only dominant males would not provide the desired reduction in female fertility and overall population growth rate, assuming that the numbers of fertile females are not changed. While bands with vasectomized harem stallions tended to have fewer foals, breeding by bachelors and subordinate stallions meant that population growth still occurred – female fertility was not dramatically reduced. Collins and Kasbohm (2016) demonstrated that there was a reduced fertility rate in a feral horse herd with both spayed and vasectomized horses – some geldings were also present in that herd. Statistically significant reductions in mare fertility rates were only observed in the first year after geldings were introduced to a herd in Utah (King et al., 2022). Garrott and Siniff (1992) concluded from their modeling that male sterilization would effectively cause there to be zero population growth (the point where births roughly equal deaths) only if a large proportion of males (i.e., >85%) could be sterilized. In cases where the goal of harem stallion sterilization is to reduce population growth rates, success appears to be dependent on a stable group structure, as strong bonds between a stallion and mares reduce the probability of a mare mating an extra-group stallion (Nelson, 1980; Garrott & Siniff, 1992; Eagle et al., 1993; Asa, 1999). At Conger HMA a fraction of geldings that were returned to the range with their social band did continue to live with females, apparently excluding fertile stallions, for at least 2 years (King et al., 2022).

Despite these studies, neutered males can be used to reduce overall growth rates in a management strategy that does not rely on any expectation that geldings would retain harems or lead to a reduction in per-female fertility rates. The primary goal of including neutered males in a herd need not necessarily be to reduce female fertility (although that may be one result). Rather, by including some neutered males in a herd that also has fertile mares and stallions, the neutered males would take some of the spaces toward AML that would otherwise be taken by fertile females. If the total number of horses is constant but neutered males are included in the herd, this can reduce the number of fertile mares, therefore reducing the absolute number of foals produced. Put another way, if neutered males occupy spaces toward AML that would otherwise be filled by fertile mares, that can reduce growth rates merely by the fact of causing there to be a lower starting number of fertile mares.

Direct Effects of Neutering

No animals which appear to be distressed, injured, or in poor health or condition would be selected for gelding. Stallions would not typically be neutered within 72 hours of capture. The surgery would be performed by a veterinarian using general anesthesia and appropriate surgical techniques. The final determination of which specific animals would be gelded would be based on the professional opinion of the attending veterinarian in consultation with the Authorized Officer (i.e., See the SOPs for neutering in the Antelope / Triple B gather EA, DOI-BLM-NV-E030-2017-010-EA).

Though neutering males is a common surgical procedure, especially gelding, some level of minor complications after surgery may be expected (Getman, 2009), and it is not always possible to predict when postoperative complications would occur. Fortunately, the most common complications are almost always self-limiting, resolving with time and exercise. Individual impacts to the stallions during and following the gelding process should be minimal and would mostly involve localized swelling and bleeding. Complications may include, but are not limited to: minor bleeding, swelling, inflammation, edema, infection, peritonitis, hydrocele, penile damage, excessive hemorrhage, and eventration (Schumacher, 1996; Searle et al., 1999; Getman, 2009). A small amount of bleeding is normal and generally subsides quickly, within 2-4 hours following the procedure. Some degree of swelling is normal, including swelling of the prepuce and scrotum, usually peaking between 3-6 days after surgery (Searle et al., 1999). Swelling should be minimized through the daily movements (exercise) of the horse during travel to and from foraging and watering areas. Most cases of minor swelling should be back to normal within 5-7 days, more serious cases of moderate to severe swelling are also self-limiting and are expected to resolve with exercise after one to 2 weeks. Older horses are reported to be at greater risk of post-operative edema, but daily exercise can prevent premature closure of the incision, and prevent fluid buildup (Getman, 2009). In some cases, a hydrocele (accumulation of sterile fluid) may develop over months or years (Searle et al., 1999). Serious complications (eventration, anesthetic reaction, injuries during handling, etc.) that result in euthanasia or mortality during and following surgery are rare (e.g., eventration rate of 0.2% to 2.6% noted in Getman, 2009, but eventration rate of 4.8% noted in Shoemaker et al., 2004) and vary according to the population of horses being treated (Getman, 2009). Normally one would expect serious complications in less than 5% of horses operated under general anesthesia, but in some populations these rates have been as high as 12% (Shoemaker, 2004). Serious complications are generally noted within 3 or 4 hours of surgery but may occur any time within the first week following surgery (Searle et al., 1999). If they occur, they would be treated with surgical intervention when possible, or with euthanasia when there is a poor prognosis for recovery. There was no observed mortality in geldings at the Conger HMA study, and geldings retained good body condition (King et al., 2022). Vasectomized stallions may remain fertile for up to 6 weeks after surgery, so it is optimal if that treatment occurs well in advance of the season of mare fertility starting in the spring (NRC, 2013). The NRC report (2013) suggested that chemical vasectomy, which has been developed for dogs and cats, may be appropriate for wild horses and burros.

For intact stallions, testosterone levels appear to vary as a function of age, season, and harem size (Khalil et al., 1998). It is expected that testosterone levels will decline over time after castration. Testosterone levels should not change due to vasectomy. Vasectomized stallions should retain their previous levels of libido. Domestic geldings had a significant prolactin response to sexual stimulation but lacked the cortisol response present in stallions (Colborn et al., 1991). Although libido and the ability to ejaculate tends to be gradually lost after castration (Thompson et al., 1980), some geldings continue to mount mares and intromit (Rios & Houpt, 1995; Schumacher, 2006).

Indirect Effects of Neutering
Other than the short-term outcomes of surgery, neutering is not expected to reduce males’ survival rates. Castration is actually thought to increase survival as males are released from the cost of reproduction (Jewell, 1997). In Soay sheep castrates survived longer than rams in the same cohort (Jewell, 1997), and Misaki horse geldings lived longer than intact males (Kaseda et al., 1997; Khalil & Murakami, 1999). Moreover, it is unlikely that a reduced testosterone level would compromise gelding survival in the wild, considering that wild mares survive with low levels of testosterone. Consistent with geldings not expending as much energy toward in attempts to obtain or defend a harem, it is expected that wild geldings may have a better body condition that wild, fertile stallions. King et al. (2022) noted that geldings maintained good body condition in the wild. In contrast, vasectomized males may continue to defend or compete for harems in the way that fertile males do, so they are not expected to experience an increase in health or body condition due to surgery.

Depending on whether an HMA is non-reproducing in whole or in part, reproductive stallions may or may not still be a component of the population’s age and sex structure. The question of whether or not a given neutered male would or would not attempt to maintain a harem in the long run is not germane to population-level management. It is worth noting, though, that the BLM is not required to manage populations of wild horses in a manner that ensures that any given individual maintains its social standing within any given harem or band. Neutering a subset of stallions would not prevent other fertile stallions and mares from continuing with the typical range of social behaviors for sexually active adults. For fertility control strategies where gelding is intended to reduce growth rates by virtue of sterile males defending harems, the NRC (2013) suggested that the effectiveness of gelding on overall reproductive rates may depend on the pre-castration social roles of those animals. Having a post-gather herd with some neutered males and a lower fraction of fertile mares necessarily reduces the absolute number of foals born per year, compared to a herd that includes more fertile mares. An additional benefit is that geldings that would otherwise be permanently removed from the range (for adoption, sale, or other disposition) may be released back onto the range where they can engage in free-roaming behaviors.

Behavioral Effects of Neutering
Feral horses typically form bands composed of an adult male with 1 to 3 adult females and their immature offspring (Feist & McCullough, 1976; Berger, 1986; Roelle et al., 2010). In many populations subordinate ‘satellite’ stallions have been observed associating with the band, although the function of these males continues to be debated (Feh, 1999; Linklater & Cameron, 2000). Juvenile offspring of both sexes leave the band at sexual maturity, which is normally around two or three years of age, but adult females may remain with the same band over a span of years (Berger, 1986). Group stability and cohesion is maintained through positive social interactions and agonistic behaviors among all members and herding and reproductive behaviors from the stallion (Ransom & Cade, 2009). Group movements and consortship of a stallion with mares is advertised to other males through the group stallion marking

dung piles as they are encountered, and over-marking mare eliminations as they occur (King & Gurnell, 2006). Burro jacks tend to not have as stable of relations with jennies and foals, as compared to what is most often seen in horses; wild burro social structure is more typically of a fission-fusion type nature (King et al., 2016).

In horses, males play a variety of roles during their lives (Deniston, 1979): after dispersal from their natal band, they generally live as bachelors with other young males, before associating with mares and developing their own breeding group as a harem stallion or satellite stallion. In any population of horses not all males would achieve harem stallion status, so all males do not have an equal chance of breeding (Asa, 1999). Stallion behavior is thought to be related to androgen levels, with breeding stallions having higher androgen concentrations than bachelors (Angle et al., 1979; Chaudhuri & Ginsberg, 1990; Khalil et al., 1998). A bachelor with low libido had lower levels of androgens, and two-year-old bachelors had higher testosterone levels than two-year-olds with undescended testicles who remained with their natal band (Angle et al., 1979).

Vasectomized males continue to attempt to defend or gain breeding access to females. It is generally expected that vasectomized WH&B would continue to behave like fertile males, given that the only physiological change in their condition is a lack of sperm in their ejaculate. If a vasectomized stallion retains a harem, the females in the harem would continue to cycle until they are fertilized by another stallion, or until the end of the breeding season. As a result, the vasectomized stallion may be involved in more aggressive behaviors to other males through the entire breeding season (Asa, 1999), which may divert time from foraging and cause him to be in poorer body condition going into winter. Ultimately, this may lead to the stallion losing control of a given harem. A feral horse herd with high numbers of vasectomized stallions retained typical harem social structure (Collins & Kasbohm, 2016). Again, it is worth noting that the BLM is not required to manage populations of wild horses in a manner that ensures that any given individual maintains its social standing within any given harem or band.

Neutering males by gelding adult male horses is expected to result in reduced testosterone production, which is expected to directly influence reproductive behaviors (NRC, 2013). However, testosterone levels alone are not a predictor of masculine behavior (Line et al., 1985; Schumacher, 2006). In domestic geldings, 20-30% continued to show stallion-like behavior, whether castrated pre- or post-puberty (Line et al., 1985). Gelding of domestic horses most commonly takes place before or shortly after sexual maturity, and age-at-gelding can affect the degree to which stallion-like behavior is expressed later in life. In intact stallions, testosterone levels peak increase up to an age of ~4-6 years and can be higher in harem stallions than bachelors (Khalil et al., 1998). It is assumed that free roaming wild horse geldings would generally exhibit reduced aggression toward other horses and reduced reproductive behaviors (NRC, 2013). In a herd that included some geldings and some fertile stallions, there were few behavioral differences between those groups, other than geldings engaging in more affiliative and less marking and reproductive behaviors (King et al., 2022). The behavior of wild horse geldings in the presence of intact stallions has not otherwise been well documented, but the literature review below can be used to make reasonable inferences about their likely behaviors.

Despite livestock being managed by neutering males for millennia, there was relatively little published research on castrates' behaviors (Hart & Jones, 1975) until recently. Stallion behaviors in wild or pasture settings are better documented than gelding behaviors, but it inferences about how the behaviors of geldings would change, how quickly any change would occur after surgery, or what effect gelding an adult stallion and releasing him back into a wild horse population would have on his behavior and that of the wider population may be surmised from the existing literature. There was a BLM-supported study in Utah focused on the individual and population-level effects of including some geldings in a free-roaming horse population (BLM, 2016; King et al., 2022). Additional inferences about likely behavioral outcomes of gelding can be made based on available literature.

The effect of castration on aggression in horses has not often been quantified. One report has noted that high levels of aggression continued to be observed in domestic horse geldings who also exhibited sexual behaviors (Rios & Houpt, 1995). Stallion-like behavior in domestic horse geldings is relatively common (Smith, 1974; Schumacher, 1996), being shown in 20-33% of cases whether the horse was castrated pre- or post-puberty (Line et al., 1985; Rios & Houpt, 1995; Schumacher, 2006). While some of these cases may be due to cryptorchidism or incomplete surgery, it appears that horses are less dependent on hormones than other mechanisms for the maintenance of sexual behaviors (Smith, 1974). Domestic geldings exhibiting masculine behavior had no difference in testosterone concentrations than other geldings (Line et al., 1985; Schumacher, 2006), and in some instances the behavior appeared context dependent (Borsberry, 1980; Pearce, 1980).

Dogs and cats are commonly neutered, and it is also common for them to continue to exhibit reproductive behaviors several years after castration (Dunbar, 1975). Dogs, ferrets, hamsters, and marmosets continued to show sexually motivated behaviors after castration, regardless of whether they had previous experience or not, although in beagles and ferrets there was a reduction in motivation post-operatively (Hart, 1968; Dunbar, 1975; Dixson, 1993; Costantini et al., 2007; Vinke et al., 2008). Ungulates continued to show reproductive behaviors after castration, with goats continuing to respond to females even a year later, although mating time and the ejaculatory response was reduced (Hart & Jones, 1975).

The likely effects of castration on geldings' social interactions and group membership can be inferred from available literature. In a pasture study of domestic horses, Van Dierendonk et al. (1995) found that social rank among geldings was directly correlated to the age at which the horse was castrated, suggesting that social experiences prior to sterilization may influence behavior afterward. Of the two geldings present in a study of semi-feral horses in England, one was dominant over the mares whereas a younger gelding was subordinate to older mares; stallions were only present in this population during a short breeding season (Tyler, 1972). A study of domestic geldings in Iceland held in a large pasture with mares and sub-adults of both sexes, but no mature stallions, found that geldings and sub-adults formed associations amongst each other that included interactions such as allo-grooming and play, and were defined by close proximity (Sigurjónsdóttir et al., 2003). These geldings and sub-adults tended to remain in a separate group from mares with foals, similar to castrated Soay sheep rams (Ovis aries) behaving like bachelors and grouping together or remaining in their mother's group (Jewell, 1997). In Japan, Kaseda et al. (1997) reported that young males dispersing from their natal harem and geldings moved to a different area than stallions and mares during the non-breeding season. Although the situation in Japan may be the equivalent of a bachelor group in natural populations, in Iceland this division between mares and the rest of the horses in the herd contradicts the dynamics typically observed in a population containing mature stallions. Sigurjónsdóttir et al. (2003) also noted that in the absence of a stallion, allo-grooming between adult females increased drastically. Other findings included increased social interaction among yearlings, display of stallion-like behaviors such as mounting by the adult females, and decreased association between females and their yearling offspring (Sigurjónsdóttir et al., 2003). In the same population in Iceland, the presence of geldings did not appear to affect the social behavior of mares (Van Dierendonck et al., 2009) or negatively influence parturition, mare-foal bonding, or subsequent maternal activities (Van Dierendonck et al., 2004). Additionally, the welfare of broodmares and their foals was not affected by the presence of geldings in the herd (Van Dierendonck et al., 2004). These findings are important because treated geldings would be returned to the range in the presence of pregnant mares and mares with foals of the year.

The likely effects of castration on geldings' home range and habitat use can also be surmised from available literature. Bands of horses tend to have distinct home ranges, varying in size depending on the habitat and varying by season, but always including a water source, forage, and places where horses can shelter from inclement weather or insects (King & Gurnell, 2005). By comparison, bachelor groups tend to be more transient, and can potentially use areas of good forage further from water sources, as they are not constrained by the needs of lactating mares in a group. The number of observations of gelded wild stallion behavior are still too few to make general predictions about whether a particular gelded stallion individual would behave like a harem stallion, a bachelor, or form a group with geldings that may forage and water differently from fertile wild horses.

Sterilizing wild horses does not change their status as wild horses under the WFRHBA (as amended). In terms of whether geldings would continue to exhibit the free-roaming behavior that defines wild horses, BLM does expect that geldings would continue to roam unhindered once they are returned to the range. Wild horse movements may be motivated by a number of biological impulses, including the search for forage, water, and social companionship that is not of a sexual nature. As such, a gelded animal would still be expected to have a number of internal reasons for moving across a landscape and, therefore, exhibiting 'free-roaming' behavior. Despite marginal uncertainty about subtle aspects of potential changes in habitat preference, there is no expectation that gelding wild horses would cause them to lose their free-roaming nature. It is worth noting that individual choices in wild horse group membership, home range, and habitat use are not protected under the WFRHBA. BLM acknowledges that geldings may exhibit some behavioral differences after surgery, compared to intact stallions, but those differences are not expected to remove the geldings' rebellious and feisty nature, or their defiance of man. While it may be that a gelded horse could have a different set of behavioral priorities than an intact stallion, the expectation is that geldings would choose to act upon their behavioral priorities in an unhindered way, just as is the case for an intact stallion. In this sense, a gelded male would be just as much 'wild' as defined by the WFRHBA as any intact stallion, even if his patterns of movement differ from those of an intact stallion. Unpublished USGS results from the Conger study herd indicate that geldings' movement patterns were not qualitatively different from those of fertile stallions, when controlling for social status as bachelor or harem stallion. Congress specified that sterilization is an acceptable management action (16 USC §1333.b.1). Sterilization is not one of the clearly defined events that cause an animal to lose its status as a wild free-roaming horse (16 USC §1333.2.C.d). Several academics have offered their opinions about whether gelding a given stallion would lead to that individual effectively losing its status as a wild horse (Rutberg, 2011; Kirkpatrick, 2012; Nock, 2017). Those opinions are based on a semantic and subjective definition of 'wild,' while BLM must adhere to the legal definition of what constitutes a wild horse, based on the WFRHBA (as amended). Those individuals have not conducted any studies that would test the speculative opinion that gelding wild stallions would cause them to become docile. BLM is not obliged to base management decisions on such opinions, which do not meet the BLM's principle and practice to "Use the best available scientific knowledge relevant to the problem or decision being addressed, relying on peer reviewed literature when it exists" (Kitchell et al., 2015).

Mare Sterilization

Sterilizing mares has already been shown to be an effective part of feral horse management that reduced herd growth rates on federal lands (Collins & Kasbohm, 2016). Herd-level birth rate is expected to decline in direct proportion to the fraction of spayed mares in the herd because spayed mares cannot become pregnant. A number of methods are available, with potentially differing effects.

Current Methods of Sterilization

This literature review of mare sterilization impacts focuses on 4 methods: pharmacological or immunocontraceptive methods, minimally invasive physical sterilization, ovariectomy via colpotomy, and ovariectomy via flank laparoscopy. The range of anticipated effects may be both physical and behavioral. Whether or not surgical mare sterilization methods are considered in any of the action alternatives in this EA, they are included here for comparison and for the sake of completeness in the review.

Pharmacological or immunocontraceptive sterilization methods would use a drug or vaccine to cause sterilization. BLM has not yet identified a pharmacological or immunocontraceptive method to sterilize mares that has been proven to sterilize wild horse mares reliably and humanely. However, there is the possibility that current or future development and testing of new methods could make an injectable sterilant available for wild horse mares. An oocyte growth factor OGF vaccine is currently under testing, for its ability to cause long-term infertility or, potentially, sterility (BLM, 2020; Bruemmer et al., 2023). Mares that received 5 or more doses of ZonaStat-H vaccine have been shown to have reduced ovarian function, and to be effectively infertile for life (Nuñez et al., 2017), and it is conceivable that the contraceptive effects of repeated treatment with GonaCon-Equine may last longer than a mare's lifespan, depending on the mare's age at treatment and the number of doses received (Baker et al., 2018, 2023). While the physiological effects of various potential methods may differ, the herd-level effects of having sterile mares as a part of a wild horse herd would be expected to be similar for minimally invasive and surgical methods. Salient differences in individual breeding behavior that result from either retaining functioning ovaries, or having no or reduce ovarian function, are discussed below.

Minimally Invasive Mare Sterilization Procedures

Population growth suppression becomes less expensive if fertility control is long-lasting (Hobbs et al. 2000), such as with spaying and neutering. For the purposes of this EA, 'minimally invasive sterilization' is defined to be the minimally invasive sterilization of a female horse (mare) by physical means. The physical means considered here include forms of oviduct blockage; for the purposes of this analysis, these are considered minimally invasive insofar as no incisions are required. Unlike in dog and cat spaying, these minimally invasive forms of mare sterilization do not entail removal of the ovaries or uterus. Only healthy mares in BCS score of 3 or greater would be considered.

The specific minimally invasive sterilization procedures could include any form of procedure that leads a mare to be unable to become pregnant, or to maintain a pregnancy, but that does not entail incision by scalpel. The two transcervical procedures analyzed below are physical, minimally invasive sterilization methods that cause long-term blockage of the oviduct, so that fertile eggs cannot go from the ovaries to the uterus. A detailed analysis of those methods and their expected effects is included in CAWP (BLM, 2021).

As is the case for IUDs, candidate mares for minimally invasive sterilization procedure treatment would need to be screened by a veterinarian to ensure they are not pregnant, because any transcervical procedures can cause a pregnancy to terminate. If palpation or ultrasound indicate that the mare is pregnant, then that mare would not be considered for the minimally invasive sterilization procedure.

One form of minimally invasive oviduct blockage procedure, "endoscopic oviduct ablation," infuses medical-grade N-butyl cyanoacrylate glue into the oviduct (Bigolin et al., 2009). In the procedure, the veterinarian passes an endoscope through the cervix, to visualize the interior of the uterus. Treated mares would stand in a padded, hydraulic chute. Banamine may be administered intravenously prior to the procedure to minimize transient colic (abdominal cramping) following the procedure. Ketamine may be added on an as needed basis for additional standing chemical restraint. Fecal material is removed from the rectum, the tail is wrapped and suspended, the perineal and vaginal areas are cleansed. A sterilized, flexible endoscope would be placed into the vaginal vault and advanced through the cervix in an atraumatic manner. A veterinary team is required to manipulate and operate the endoscope monitor, insert, and hold the endoscope, manipulate, and position the fine-tipped catheter into the oviduct, and infuse the fluid into the oviduct. The uterus would be partially inflated with filtered room air to visualize the oviduct papilla located at the proximal end of the uterine horn. A sterile catheter is guided to each uterotubal junction (which is the entrance to the oviduct), and medical-grade glue (N-butyl cyanoacrylate) is introduced to the oviduct, where it causes blockage. After the procedure, the uterus could be infused with an antibiotic and saline to minimize the potential for infection secondary to any unintended bacterial contamination. The mares are monitored initially for 10 minutes and observed by a veterinarian twice per day for 10-14 days, but no further pain management is expected to be needed. Any mare showing signs of postoperative complications would receive treatment as indicated by a veterinarian. The total duration of the procedure per mare is expected to be less than 30 minutes. A pilot project used this approach in six domestic mares and has shown that after three years of breeding by a fertile stallion, all six mares remained infertile (Dr. I. Liu, UC Davis Emeritus Professor, personal communication to BLM). After receiving support from the California legislature (California Legislature, 2019), researchers used a similar method in burros but with electrocauterization of the utero-tubular junction; a five-person team completed the procedure in 20-30 minutes (Dr. E. Davis, UC Davis, 2021 personal communication to BLM).

Another form of minimally invasive oviduct blockage procedure, "endoscopic laser ablation of the oviduct papilla," is similar to the procedure described above, except that the oviducts are blocked via heating from a laser to ablate the oviduct papilla. The diode laser is expected to immediately "seal" the oviduct opening, and the resulting inflammatory reaction is expected to result in additional scar tissue formation, forming a barrier to the passage of eggs from the ovary to the uterus. Local anesthesia could be dripped directly onto each oviduct papilla to minimize any discomfort. This method has been used successfully in Georgia (Edwards et al., 2021) and California (unpublished results).

Neither of these minimally invasive procedures damages the ovaries. The mare would be sterile, although the mare would continue to have estrus cycles. Because of the retention of estrus cycles, it is expected that behavioral outcomes of either method would be similar to those observed for PZP vaccine treated mares. Namely, mares would continue with hormonal cycles and associated breeding behaviors during the typical breeding season.

If the minimally invasive sterilization techniques are either of the two noted above, then mares chosen for the minimally invasive sterilization procedure could include adult females and immature females estimated to be older than 8 months. Immature females could be included because there are no concerns regarding space for instruments, as an endoscope and associated instruments used along with the endoscope are the only tools used, and only open (non-pregnant) females would receive the procedure.

Minimally invasive, physical sterilization procedure could include any physical form of sterilization that does not involve removal of the ovaries and entail only minimal or no incisions. Such procedures could include any form of physical procedure that leads a mare to be unable to become pregnant, or to maintain a pregnancy. For example, in endoscopic oviduct ablation, minimally invasive sterilization causes a long-term blockage of the oviduct by infusion of a surgical-grade glue into the oviducts, so that fertile eggs cannot go from the ovaries to the uterus (Bigolin et al., 2009). Or, in endoscopic laser ablation of the oviduct papilla, scarring caused by heat applied at the uterotubal junction prevents eggs from reaching the uterus (Edwards et al., 2021). These two procedures use trans-cervical endoscopy, so any treated mares would first need to have been screened by a veterinarian (e.g., using trans-rectal ultrasonography) to ensure they are not pregnant. Endoscopic approaches also require temporary insufflation of the uterus, to allow the veterinarian to fully visualize the internal structures. The result of such minimally invasive procedures that prevent pregnancy but do not harm the ovaries is that the mare would be sterile, although the mare would continue to have estrus cycles.

Ovariectomy via colpotomy is a surgical technique in which there is no external incision, reducing susceptibility to infection. Ovariectomy via colpotomy, has been an established veterinary technique since 1903 (Loesch & Rodgerson, 2003; NRC, 2013). Spaying via colpotomy has the advantage of not leaving any external wound that could become infected. For this reason, it has been identified as a good choice for sterilization of feral or wild mares (Rowland et al., 2018). The procedure has a relatively low complication rate, although post-surgical mortality and morbidity are possible, as with any surgery. For this reason, ovariectomy via colpotomy has been identified as a good choice for feral or wild horses (Rowland et al., 2018). Ovariectomy via colpotomy is a relatively short surgery, with a relatively quick expected recovery time. In 1903, Williams first described a vaginal approach, or colpotomy, using an ecraseur to ovariectomize mares (Loesch & Rodgerson, 2003). The ovariectomy via colpotomy procedure has been conducted for over 100 years, normally on open (non-pregnant), domestic mares. It is expected that the surgeon should be able to access ovaries with ease in mares that are in the early- or mid-stage of pregnancy. The anticipated risks associated with the pregnancy are described below. When wild horses are gathered or trapped for fertility control treatment there would likely be mares in various stages of gestation. Removal of the ovaries is permanent and 100 percent effective, however the procedure is not without risk.

Ovariectomy via flank laparoscopy (Lee & Hendrickson, 2008; Devick et al., 2018; Easley et al., 2018) is commonly used in domestic horses for application in mares due to its minimal invasiveness and full observation of the operative field. Ovariectomy via flank laparoscopy was seen as the lowest risk method considered by a panel of expert reviewers convened by USGS (Bowen, 2015). In a review of unilateral and bilateral laparoscopic ovariectomy on 157 mares, Röcken et al. (2011) found that 10.8% of mares had minor post-surgical complications and recorded no mortality. Mortality due to this type of surgery, or post-surgical complications, is not expected, but is a possibility. In two studies, ovariectomy by laparoscopy or endoscope-assisted colpotomy did not cause mares to lose weight, and there was no need for rescue analgesia following surgery (Pader et al., 2011; Bertin et al., 2013). This surgical approach entails three small incisions on the animal's flank, through which three cannulae (tubes) allow entry of narrow devices to enter the body cavity: these are the insufflator, endoscope, and surgical instrument. The surgical procedure involves the use of narrow instruments introduced into the abdomen via cannulas for the purpose of transecting or sealing (Easley 2018) the ovarian pedicle, but the insufflation should allow the veterinarian to navigate inside the abdomen without damaging other internal organs. The insufflator blows air into the cavity to increase the operating space between organs, and the endoscope provides a video feed to visualize the operation of the surgical instrument. This procedure can require a relatively long duration of surgery but tends to lead to the lowest post-operative rates of complications. Flank laparoscopy may leave three small (<5 cm) visible scars on one side of the horse's flank, but even in performance horses these scars are considered minimal. It is expected that the tissues and musculature under the skin at the site of the incisions in the flank would heal quickly, leaving no long-lasting effects on horse health. Monitoring for up to two weeks at the facility where surgeries take place would allow for veterinary inspection of wound healing. The ovaries may be dropped into the abdomen, but this is not expected to cause any health problem; it is usually done in ovariectomies in cattle (e.g., the Willis Dropped Ovary Technique) and Shoemaker et al. (2014) found no problems with revascularization or necrosis in a study of young horses using this method.

Effects of Sterilization on Pregnancy and Foal

The physical, behavioral, and herd-level effects of immunocontraceptives have been addressed elsewhere in this review. In the case of repeated PZP vaccine or GonaCon applications that cause infertility through the duration of a given mare's life, that effects of that form of treatment have been discussed previously; neither vaccine appears to disrupt pregnancy or foal development. OGF vaccine effects on fetal development are unknown, as no pregnant mares have been injected with this vaccine to date; use on pregnant mares may be limited until further information is available.

Trans-cervical, minimally invasive sterilization methods are not suitable for pregnant mares, because disruption of the cervix may lead to termination of the pregnancy. Therefore, any mares under consideration for such methods must first be screened for pregnancy, such as via transrectal ultrasound.

The average mare gestation period ranges from 335 to 340 days (Evans et al., 1977, p. 373). There are few peer-reviewed studies documenting the effects of surgical ovariectomy on the success of pregnancy in a mare. A National Research Council of the National Academies of Sciences committee that reviewed research proposals in 2015 explained, "The mare's ovaries and their production of progesterone are required during the first 70 days of pregnancy to maintain the pregnancy" (NRC, 2015). In female mammals, less progesterone is produced when ovaries are removed, but production does not cease (Webley & Johnson, 1982). In 1977, Evans et al. stated that by 200 days, the secretion of progesterone by the corpora lutea is insignificant because removal of the ovaries does not result in abortion (p. 376). "If this procedure were performed in the first 120 days of pregnancy, the fetus would be resorbed or aborted by the mother. If performed after 120 days, the pregnancy should be maintained. The effect of ovary removal on a pregnancy at 90–120 days of gestation is unpredictable because it is during this stage of gestation that the transition from corpus luteum to placental support typically occurs" (NRC, 2015). In 1979, Holtan et al. evaluated the effects of bilateral ovariectomy at selected times between 25 and 210 days of gestation on 50 mature pony mares. Their results show that abortion (resorption) of the conceptus (fetus) occurred in all 14 mares ovariectomized before day 50 of gestation, that pregnancy was maintained in 11 of 20 mares after ovariectomy between days 50 and 70, and that pregnancy was not interrupted in any of 12 mares ovariectomized on days 140 to 210. Those results are similar to the suggestions of the NRC committee (2015). For those pregnancies that are maintained following an ovariectomy procedure, likely those past approximately 120 days, the development of the foal is not expected to be affected. However, because this procedure is not commonly conducted on pregnant mares the rate of complications to the fetus has not yet been quantified. There is the possibility that entry to the abdominal cavity could cause premature births related to inflammation. However, after five months the placenta should hormonally support the pregnancy regardless of the presence or absence of ovaries. Gestation length was similar between ovariectomized and control mares (Holtan et al., 1979).

Direct Effects of Sterilization

The direct effects of immunocontraceptive PZP vaccines and GonaCon-Equine have been discussed previously. In cases where PZP vaccines have been administered enough times to cause effective sterility, the mechanism of action may be related to long-term reduction in ovarian activity (Nolan et al., 2018c). The direct effects of OGF vaccine treatment were discussed by BLM (2020) and may include an injection site reaction that is comparable to that of GonaCon-Equine; a brief period of heightened inflammation and mild fever that is characteristic of a successful immune response; development of an immune response against GDF9 and BMP15, with related reductions in the concentration of those proteins; and a reduction in estrus activity.

The direct effects of successful minimally invasive mare sterilization procedures are sterility, for example through occlusion of the oviduct with surgical glue and associated tissue damage, or creation of scar tissue in part of the oviduct. Hysteroscopy is a common procedure in humans (WebMD, 2014). Because such minimally invasive procedures do not involve major incisions or removal of ovaries, there is no risk of hemorrhage, failure of sutures, or prolonged discomfort. There is the potential for mild, transient colic (abnormal cramping) after the procedure due to temporary inflation and expansion of the uterus. Use of analgesics prior to any procedure should minimize this incidence. Side effects of minimally invasive sterilization procedures may include mild discomfort in the short term, for example at the location where the oviduct is blocked. For example, if surgical grade glue is placed in the oviduct or if a laser is used to ablate the oviduct papilla, that may cause transient irritation. For this reason, systemic and / or topical analgesics are generally provided before or during the procedure. An NRC review of the endoscopic laser ablation of the oviduct papilla technique concluded that the method is relatively non-invasive, with a relatively low risk of complications (NRC, 2015); the expected severe complication rate for the laser ablation procedure may be lower than 1%. Ablation of the oviduct via cyanoacrylate glue has been performed successfully in mares at UC Davis, and laser ablation of the oviduct papilla has been performed successfully in burros and horses, in California and Georgia. In addition, other transcervical endoscopic procedures (including the use of a laser diode) are not uncommon in mares (Blikslager et al., 1993; Griffin & Bennet, 2002; Ley et al., 2002; Brinsko, 2014).

Between 2009 and 2011, the Sheldon NWR in Nevada conducted ovariectomy via colpotomy surgeries (August through October) on 114 feral mares and released them back to the range with a mixture of sterilized stallions and untreated mares and stallions (Collins & Kasbohm, 2016). Gestational stage was not recorded, but a majority of the mares were pregnant (Gail Collins, US Fish and Wildlife Service (USFWS), pers. comm.). Only a small number of mares were very close to full term. Those mares with late term pregnancies did not receive surgery as the veterinarian could not get good access to the ovaries due to the position of the foal (Gail Collins, USFWS, pers. comm.). After holding the mares for an average of 8 days after surgery for observation, they were returned to the range with other treated and untreated mares and stallions (Collins & Kasbohm, 2016). During holding the only complications were observed within 2 days of surgery. The observed mortality rate for ovariectomized mares following the procedure was less than 2 percent (Collins & Kasbohm, 2016; Pielstick pers. comm.). During the Sheldon NWR ovariectomy study, mares generally walked out of the chute and started to eat; some would raise their tail and act as if they were defecating; however, in most mares one could not notice signs of discomfort (Bowen, 2015). In their discussion of ovariectomy via colpotomy, McKinnon and Vasey (2007) considered the procedure safe and efficacious in many instances, able to be performed expediently by personnel experienced with examination of the female reproductive tract, and associated with a complication rate that is similar to or less than male castration. Nevertheless, all surgery is associated with some risk. Loesch et al. (2003) lists that following potential risks with colpotomy: pain and discomfort; injuries to the cervix, bladder, or a segment of bowel; delayed vaginal healing; eventration of the bowel; incisional site hematoma; intraabdominal adhesions to the vagina; and chronic lumbar or bilateral hind limb pain. Most horses, however, tolerate ovariectomy via colpotomy with very few complications, including feral horses (Collins & Kasbohm, 2016). Evisceration is also a possibility, but these complications are considered rare (Prado & Schumacher, 2017). Mortality due to surgery or post-surgical complications is not anticipated, but it is a possibility and therefore every effort would be made to mitigate risks.

In September 2015, the BLM solicited the USGS to convene a panel of veterinary experts to assess the relative merits and drawbacks of several surgical ovariectomy techniques that are commonly used in domestic horses for potential application in wild horses. A table summarizing the various methods was sent to the BLM (Bowen, 2015) and provides a concise comparison of several methods. Of these, ovariectomy via colpotomy was found to be relatively safe when practiced by an experienced surgeon and was associated with the shortest duration of potential complications after the operation. The panel discussed the potential for evisceration through the vaginal incision with this procedure. In marked contrast to a suggestion by the NRC report (2013), this panel of veterinarians identified evisceration as not being a probable risk associated with ovariectomy via colpotomy and "none of the panel participants had had this occur nor had heard of it actually occurring" (Bowen, 2015).

Most ovariectomy surgeries on mares have low morbidity[3] and with the help of medications, pain and discomfort can be mitigated. Pain management is an important aspect of any ovariectomy (Rowland et al., 2018); according to surgical protocols that would be used, a long-lasting direct anesthetic would be applied to the ovarian pedicle, and systemic analgesics in the form of butorphanol and flunixin meglumine would be administered, as is compatible with accepted animal husbandry practices. In a study of the effects of bilateral ovariectomy via colpotomy on 23 mares, Hooper et al., (1993) reported that postoperative problems were minimal (1 in 23, or 4%). Hooper et al. (1993) noted that four other mares were reported by owners as having some problems after surgery, but that evidence as to the role the surgery played in those subsequent problems was inconclusive. In contrast Röcken et al. (2011) noted a morbidity of 10.8% for mares that were ovariectomized via a flank laparoscopy. "Although 5 mares in our study had problems (repeated colic in 2 mares, signs of lumbar pain in 1 mare, signs of bilateral hind limb pain in 1 mare, and clinical

[3] Morbidity is defined as the frequency of the appearance of complications following a surgical procedure or other treatment. In contrast, mortality is defined as an outcome of death due to the procedure.

signs of peritonitis in 1 mare) after surgery, evidence is inconclusive in each as to the role played by surgery" (Hooper et al. 1993). A recent study showed a 2.5% complication rate where one mare of 39 showed signs of moderate colic after laparoscopic ovariectomy (Devick, 2018, personal communication).

Behavioral Effects of Mare Sterilization
All fertility control methods affect physiology or behavior of a mare (NRC, 2013). Any action taken to alter the reproductive capacity of an individual has the potential to affect hormone production and therefore behavioral interactions and ultimately population dynamics in unforeseen ways (Ransom et al., 2014). The health and behavioral effects of sterilizing wild horse mares that live with other fertile and infertile wild horses has not been well documented, but the literature review below can be used to make reasonable inferences about their likely behaviors.

The behavioral effects of PZP vaccines and GonaCon-Equine have been discussed previously. For the OGF vaccine, a paired immune reaction to two proteins (GDF9 and BMP15) can prevent the completion of oocyte development, with the result being that successfully treated mares do not exhibit estrus cycles (Bruemmer et al., 2023). As a result, the behavioral and herd-level effects of OGF vaccine treatment are expected to be similar to those documented for GonaCon-Equine; namely, a reduced incidence of breeding behaviors, but a continuation of affiliative behaviors within the social band (see previous discussion of effects of GonaCon-Equine).

Horses are anovulatory (do not ovulate/express estrous behavior) during the short days of late fall and early winter, beginning to ovulate as days lengthen and then cycling roughly every 21 days during the warmer months, with about 5 days of estrus (Asa et al., 1979; Crowell-Davis, 2007). Estrus in mares is shown by increased frequency of proceptive behaviors: approaching and following the stallion, urinating, presenting the rear end, clitoral winking, and raising the tail towards the stallion (Asa et al., 1979; Crowell-Davis, 2007). In most mammal species, other than primates, estrus behavior is not shown during the anovulatory period, and reproductive behavior is considered extinguished following spaying (Hart & Eckstein, 1997). However, mares may continue to demonstrate estrus behavior during the anovulatory period (Asa et al., 1980).

The behavioral effects of minimally invasive mare sterilization methods that cause no change in ovarian functionality would be expected to be similar to those observed in mares treated with a small number of doses of PZP vaccine (i.e., those in which ovarian functionality is not impaired). Those behavioral outcomes are discussed previously, but include a continuation of estrus cycling, and associated proceptive and breeding behaviors, including copulation. As a result of the expectation that the minimally invasive procedures would have similar behavioral effects as treatment with PZP, BLM does not anticipate any need to study the behavioral effects of minimally invasive mare sterilization, in which functional ovaries are retained. Sterile mares with functional ovaries would be expected to continue to engage in breeding activities, although they would not become pregnant. There is the possibility that such mares may change social bands at a greater rate than fertile mares (Nuñez et al., 2017).

Ovariectomized mares may continue to exhibit estrous behavior (Scott & Kunze, 1977; Kamm & Hendrickson, 2007; Crabtree, 2016), with one study finding that 30% of mares showed estrus signs at least once after surgery (Roessner et al., 2015) and only 60% of ovariectomized mares cease estrous behavior following surgery (Loesch & Rodgerson, 2003). Mares continue to show reproductive behavior following ovariectomy due to non-endocrine support of estrus behavior, specifically steroids from the adrenal cortex. Continuation of this behavior during the non-breeding season has the function of maintaining social cohesion within a horse group (Asa et al., 1980; Asa et al., 1984; NRC, 2013). This may be a unique response of the horse (Bertin et al., 2013), as spaying usually greatly reduces female sexual behavior in companion animals (Hart & Eckstein, 1997). In six ponies, mean monthly plasma luteinizing hormone[4] levels in ovariectomized mares were similar to intact mares during the anestrous season, and during the breeding season were similar to levels in intact mares at mid-estrus (Garcia & Ginther, 1976).

The likely effects of spaying on mares' social interactions and group membership can be inferred from available literature, even though wild horses have rarely been spayed and released back into the wild, resulting in few studies

[4] Luteinizing hormone (LH) is a glycoprotein hormone produced in the pituitary gland. In females, a sharp rise of LH triggers ovulation and development of the corpus luteum. LH concentrations can be measured in blood plasma.

that have investigated their behavior in free-roaming populations. Wild horses and burros are instinctually herd-bound, and this behavior is expected to continue. Overall, the BLM anticipates that some spayed mares may continue to exhibit estrus behavior which could foster band cohesion. If free ranging ovariectomized mares show estrous behavior and occasionally allow copulation, interest of the stallion may be maintained, which could foster band cohesion (NRC, 2013). This last statement could be validated by the observations of group associations on the Sheldon NWR where feral mares were ovariectomized via colpotomy and released back on to the range with untreated horses of both sexes (Collins & Kasbohm, 2016). No data were collected on inter- or intra-band behavior (e.g. estrous display, increased tending by stallions, etc.), during multiple aerial surveys in years following treatment, all treated individuals appeared to maintain group associations, and there were no groups consisting only of treated males or only of treated females (Collins & Kasbohm, 2016). In addition, of solitary animals documented during surveys, there were no observations of solitary treated females (Collins & Kasbohm, 2016). These data help support the expectation that ovariectomized mares would not lose interest in or be cast out of the social dynamics of a wild horse herd. As noted by the NRC (2013), the ideal fertility control method would not eliminate sexual behavior or change social structure substantially.

A study conducted for 15 days in January 1978 (Asa et al., 1980), compared the sexual behavior in ovariectomized and seasonally anovulatory (intact) pony mares and found that there were no statistical differences between the two conditions for any measure of proceptivity or copulatory behavior, or days in estrous. This may explain why treated mares at Sheldon NWR continued to be accepted into harem bands; they may have been acting the same as a non-pregnant mare. Five to ten percent of pregnant mares exhibit estrous behavior (Crowell-Davis, 2007). Although the physiological cause of this phenomenon is not fully understood (Crowell-Davis, 2007), it is thought to be a bonding mechanism that assists in the maintenance of stable social groups of horses year-round (Ransom et al., 2014b). The complexity of social behaviors among free-roaming horses is not entirely centered on reproductive receptivity, and fertility control treatments that suppress the reproductive system and reproductive behaviors should contribute to minimal changes to social behavior (Ransom et al., 2014b; Collins & Kasbohm, 2016).

BLM expects that wild horse harem structures would continue to exist under the Proposed Action because fertile mares, stallions, and their foals would continue to be a component of the herd. It is not expected that spaying a subset of mares would significantly change the social structure or herd demographics (age and sex ratios) of fertile wild horses.

'Foal stealing,' where a near-term pregnant mare steals a neonate foal from a weaker mare, is unlikely to be a common behavioral result of including sterilized mares in a wild horse herd, no matter the method of sterilization. McDonnell (2012) noted that "foal stealing is rarely observed in horses, except under crowded conditions and synchronization of foaling," such as in horse feed lots. Those conditions are not likely in the wild, where pregnant mares would be widely distributed across the landscape, and where the expectation is that parturition dates would be distributed across the normal foaling season.

Indirect Effects of Mare Sterilization
The free-roaming behavior of wild horses is not anticipated to be affected by mare sterilization, as the definition of free-roaming is the ability to move without restriction by fences or other barriers within a HMA (BLM, 2010) and there are no permanent physical barriers being proposed.

In domestic animals, sterilization is often associated with weight gain and associated increase in body fat (Fettman et al., 1997; Becket et al., 2002; Jeusette et al., 2006; Belsito et al., 2009; Reichler, 2009; Camara et al., 2014). Spayed cats had a decrease in fasting metabolic rate, and spayed dogs had a decreased daily energy requirement, but both had increased appetite (O'Farrell & Peachey, 1990; Hart & Eckstein, 1997; Fettman et al., 1997; Jeusette et al., 2004). In wild horses, contracepted mares tend to be in better body condition that mares that are pregnant or that are nursing foals (Nuñez et al., 2010); the same improvement in body condition is likely to take place in spayed mares. In horses, surgical sterilization through ovariectomy has the potential to increase risk of equine metabolic syndrome (leading to obesity and laminitis), but both blood glucose and insulin levels were similar in mares before and after ovariectomy over the short-term (Bertin et al., 2013). In wild horses the quality and quantity of forage, and frequent exercise, is unlikely to be sufficient to promote over-eating and obesity.

Coit et al. (2009) demonstrated that spayed dogs have elevated levels of LH-receptor and GnRH-receptor mRNA in the bladder tissue, and lower contractile strength of muscles. They noted that urinary incontinence occurs at elevated levels in spayed dogs and in post-menopausal women. Thus, it is reasonable to suppose that some ovariectomized mares could also suffer from elevated levels of urinary incontinence.

Sterilization had no effect on movements and space use of feral cats or brushtail possums (Ramsey, 2007; Guttilla & Stapp, 2010), or greyhound racing performance (Payne, 2013). Rice field rats (*Rattus argentiventer*) tend to have a smaller home range in the breeding season, as they remain close to their litters to protect and nurse them. When surgically sterilized, rice field rats had larger home ranges and moved further from their burrows than hormonally sterilized or fertile rats (Jacob et al., 2004). Spayed possums and foxes (*Vulpes vulpes*) had a similar core range area after spay surgery compared to before and were no more likely to shift their range than intact females (Saunders et al., 2002; Ramsey, 2007).

The likely effects of sterilization on mares' home range and habitat use can also be surmised from available literature. Bands of horses tend to have distinct home ranges, varying in size depending on the habitat and varying by season, but always including a water source, forage, and places where horses can shelter from inclement weather or insects (King & Gurnell, 2005). It is unlikely that sterilized mares would change their spatial ecology, but not having constraints of gestation and lactation may mean they can spend more time away from water sources and increase their home range size. Lactating mares need to drink every day, but during the winter when snow can fulfill water needs or when not lactating, horses can traverse a wider area (Feist & McCullough, 1976; Salter, 1979). During multiple aerial surveys in years following the mare ovariectomy study at the Sheldon NWR, it was documented that all treated individuals appeared to maintain group associations, no groups consisted only of treated females, and none of the solitary animals observed were treated females (Collins & Kasbohm, 2016). Given that treated females maintained group associations, this indicates that their movement patterns and distances may be unchanged.

Sterilizing wild horses does not change their status as wild horses under the WFRHBA (as amended). In terms of whether sterile mares would continue to exhibit the free-roaming behavior that defines wild horses, BLM does expect that sterile mares would continue to roam unhindered. Wild horse movements may be motivated by a number of biological impulses, including the search for forage, water, and social companionship that is not of a sexual nature. As such, a sterilized animal would still be expected to have several internal reasons for moving across a landscape and, therefore, exhibiting 'free-roaming' behavior. Despite marginal uncertainty about subtle aspects of potential changes in habitat preference, there is no expectation that spaying wild horses would cause them to lose their free-roaming nature.

In this sense, a sterilized wild mare would be just as much 'wild' as defined by the WFRHBA as any fertile wild mare, even if that mare's patterns of movement did differ slightly. Congress specified that sterilization is an acceptable management action (16 USC §1333.b.1). Sterilization is not one of the clearly defined events that cause an animal to lose its status as a wild free-roaming horse (16 USC §1333.2.C.d). As noted in the discussion of neutering, any opinions based on a semantic and subjective definition of what constitutes a 'wild' horse are not legally binding for BLM, which must adhere to the legal definition of what constitutes a wild free-roaming horse[5], based on the WFRHBA (as amended). BLM is not obliged to base management decisions on personal opinions, which do not meet the BLM's principle and practice to "Use the best available scientific knowledge relevant to the problem or decision being addressed, relying on peer reviewed literature when it exists" (Kitchell et al., 2015).

Sterilization is not expected to reduce mare survival rates on public rangelands. Individuals receiving fertility control often have reduced mortality and *increased* longevity due to being released from the costs of reproduction (Kirkpatrick & Turner, 2008). Similar to contraception studies, in other wildlife species a common trend has been higher survival of sterilized females (Twigg et al., 2000; Saunders et al., 2002; Ramsey, 2005; Jacob et al., 2008; Seidler & Gese, 2012). Observations from the Sheldon NWR provide some insight into long-term effects of ovariectomy on feral horse survival rates. The sterilized mares in Sheldon NWR were returned to the range along with

[5] "Wild free-roaming horses and burros" means all unbranded and unclaimed horses and burros on public lands of the United States.

untreated mares. Between 2007 and 2014, mares were captured, a portion treated, and then recaptured. There was a minimum of 1 year between treatment and recapture; some mares were recaptured a year later, and some were recaptured several years later. The long-term survival rate of treated wild mares appears to be the same as that of untreated mares (Collins & Kasbohm, 2016). Recapture rates for released mares were similar for treated mares and untreated mares.

Effects on Bone Histology
There is no known mechanism by which bone development would change in mares treated with pharmacological or immunological sterilization methods, or with minimally invasive sterilization methods. The BLM knows of no scientific, peer-reviewed literature that documents bone density loss in mares following ovariectomy. A concern has been raised in an opinion article (Nock, 2013) that ovary removal in mares could lead to bone density loss. That opinion article was not peer reviewed nor was it based on research in wild or domestic horses, so it does not meet the BLM's standard for "best available science" on which to base decisions (Kitchell et al., 2015). Hypotheses that are forwarded in Nock (2013) appear to be based on analogies from modern humans leading sedentary lives. Post-menopausal women appear to have a greater chance of developing osteoporosis (Scholz-Ahrens et al., 1996), but BLM is not aware of any research examining bone loss in horses following ovariectomy. Bone loss in humans has been linked to reduced circulating estrogen. There have been conflicting results when researchers have attempted to test for an effect of reduced estrogen on animal bone loss rates in animal models; all experiments have been on laboratory animals, rather than free-ranging wild animals. While some studies found changes in bone cell activity after ovariectomy leading to decreased bone strength (Jerome et al., 1997; Baldock et al., 1998; Huang et al., 2002; Sigrist et al., 2007), others found that changes were moderate and transient or minimal (Scholz-Ahrens et al., 1996; Lundon et al., 1994; Zhang et al., 2007), and even returned to normal after 4 months (Sigrist et al., 2007).

Consistent and strenuous use of bones, for instance using jaw bones by eating hard feed, or using leg bones by travelling large distances, may limit the negative effects of estrogen deficiency on micro-architecture (Mavropoulos et al., 2014). The effect of exercise on bone strength in animals has been known for many years and has been shown experimentally (Rubin et al., 2001). Dr. Simon Turner, Professor Emeritus of the Small Ruminant Comparative Orthopaedic Laboratory at Colorado State University, conducted extensive bone density studies on ovariectomized sheep, as a model for human osteoporosis. During these studies, he did observe bone density loss on ovariectomized sheep, but those sheep were confined in captive conditions, fed twice a day, had shelter from inclement weather, and had very little distance to travel to get food and water (Simon Turner, Colorado State University Emeritus, written comm., 2015). Dr. Turner indicated that an estrogen deficiency (no ovaries) could potentially affect a horse's bone metabolism, just as it does in sheep and human females when they lead a sedentary lifestyle, but indicated that the constant weight bearing exercise, coupled with high exposure to sunlight ensuring high vitamin D levels, are expected to prevent bone density loss (Simon Turner, Colorado State University Emeritus, written comm., 2015).

Home range size of horses in the wild has been described as 4.2 to 30.2 square miles (Green & Green, 1977) and 28.1 to 117 square miles (Miller, 1983). A study of distances travelled by feral horses in "outback" Australia shows horses travelling between 5 and 17.5 miles per 24-hour period (Hampson et al., 2010a), travelling about 11 miles a day even in a very large paddock (Hampson et al., 2010b). Thus, extensive movement patterns of wild horses are expected to help prevent bone loss. The expected daily movement distance would be far greater in the context of larger pastures typical of BLM long-term holding facilities in off-range pastures. A horse would have to stay on stall rest for years after removal of the ovaries in order to develop osteoporosis (Simon Turner, Colorado State University Emeritus, written comm., 2015) and that condition does not apply to any wild horses turned back to the range or any wild horses that go into off-range pastures.

Genetic Effects of Mare Sterilization and Neutering
It is true that spayed females and neutered males are unable to contribute to the genetic diversity of the herd. BLM is not obligated to ensure that any given individual in a herd has the chance to sire a foal and pass on genetic material. Management practices in the BLM Wild Horse and Burro Handbook (2010) include measures to increase population genetic diversity in reproducing herds where monitoring reveals a cause for concern about low levels of observed heterozygosity. These measures include increasing the sex ratio to a greater percentage of fertile males than fertile

females (and thereby increasing the number of males siring foals) and bringing new animals into a herd from elsewhere.
In a hypothetical herd that is managed to be entirely non-reproducing, it would not be a concern to maintain genetic diversity because the management goal would be that animals in such a herd would not breed.

In reproducing herds where large numbers of wild horses have recent and / or an ongoing influx of breeding animals from other areas with wild or feral horses, spaying and neutering is not expected to cause an unacceptable loss of genetic diversity or an unacceptable increase in the inbreeding coefficient. In any diploid population, the loss of genetic diversity through inbreeding or drift can be prevented by large effective breeding population sizes (Wright, 1931) or by introducing new potential breeding animals (Mills & Allendorf, 1996). The NRC report (2013) recommended that single HMAs should not be considered as isolated genetic populations. Rather, managed herds of wild horses should be considered as components of interacting metapopulations, with the potential for interchange of individuals and genes taking place as a result of both natural and human-facilitated movements. It is worth noting that, although maintenance of genetic diversity at the scale of the overall population of wild horses is an intuitive management goal, there are no existing laws or policies that require BLM to maintain genetic diversity at the scale of the individual herd management area or complex. Also, there is no Bureau-wide policy that requires BLM to allow each female in a herd to reproduce before treatment with contraceptives. Introducing 1-2 mares every generation (about every 10 years) is a standard management technique that can alleviated potential inbreeding concerns (BLM, 2010). The NRC report (2013) recommended that managed herds of wild horses would be better viewed as components of interacting metapopulations, with the potential for interchange of individuals and genes taking place as a result of both natural and human-facilitated movements.

In the last 10 years, there has been a high realized growth rate of wild horses in most areas administered by the BLM. As a result, most alleles that are present in any given mare are likely to already be well represented in that mare's siblings, cousins, and more distant relatives on the HMA. With the exception of horses in a small number of well-known HMAs that contain a relatively high fraction of alleles associated with old Spanish horse breeds (NRC, 2013), the genetic composition of wild horses in lands administered by the BLM is consistent with admixtures from domestic breeds. The NRC report (2013) includes information (pairwise genetic 'fixation index' values for sampled WH&B herds) confirming that WH&B in the vast majority of HMAs are genetically similar to animals in multiple other HMAs. As a result, in most HMAs, applying fertility control to a subset of mares is not expected to cause irreparable loss of genetic diversity. Improved longevity and an aging population are expected results of contraceptive treatment that can provide for lengthening generation time; this result would be expected to slow the rate of genetic diversity loss (Hailer et al., 2006). Based on a population model, Gross (2000) found that a strategy to preferentially treat young animals with a contraceptive led to more genetic diversity being retained than either a strategy that preferentially treats older animals, or a strategy with periodic gathers and removals.

Roelle and Oyler-McCance (2015) used the VORTEX population model to simulate how different rates of mare sterility would influence population persistence and genetic diversity, in populations with high or low starting levels of genetic diversity, various starting population sizes, and various annual population growth rates. Although those results are specific to mares, some inferences about potential effects of stallion sterilization may also be made from their results. Roelle and Oyler-McCance (2015) showed that the risk of the loss of genetic heterozygosity is extremely low except in cases where all of the following conditions are met: starting levels of genetic diversity are low, initial population size is 100 or less, the intrinsic population growth rate is low (5% per year), and very large fractions of the population are permanently sterilized. Given that 94 of 102 wild horse herds sampled for genetic diversity did not meet a threshold for concern (NRC, 2013), the starting level of genetic diversity in most wild-horse herds is relatively high.

In a breeding herd where more than 85% of males in a population are sterile, there could be genetic consequences of reduced heterozygosity and increased inbreeding coefficients, as it would potentially allow a very small group of males to dominate the breeding (Saltz et al., 2000). Such genetic consequences could be mitigated by natural movements or human-facilitated translocations (BLM, 2010). Garrott and Siniff's (1992) model predicts that gelding 50-80% of mature males in the population would result in reduced, but not halted, mare fertility rates. However, neutering males tends to have short-lived effects, because within a few years after any male sterilization treatment, a number of fertile male colts would become sexually mature stallions who could contribute genetically to the herd.

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Effects of Intrauterine Devices (IUDs)

Based on promising results from published, peer-reviewed studies in domestic mares, BLM has begun to use IUDs to control fertility as a wild horse and burro fertility control method on the range. The initial management use was in mares from the Swasey HMA, in Utah. The BLM has supported and continues to support research into the development and testing of effective and safe IUDs for use in wild horse mares (Baldrighi et al., 2017; Holyoak et al., 2021). However, existing literature on the use of IUDs in horses allows for inferences about expected effects of any management alternatives that might include use of IUDs and support the apparent safety and efficacy of some types of IUDs for use in horses. Overall, as with other methods of population growth suppression, use of IUDs and other fertility control measures are expected to help reduce population growth rates, extend the time interval between gathers, and reduce the total number of excess animals that would need to be removed from the range.

The 2013 National Research Council of the National Academies of Sciences (NRC) report considered IUDs and suggested that research should test whether IUDs cause uterine inflammation and should also test how well IUDs stay in mares that live and breed with fertile stallions. Since that report, a recent study by Holyoak et al. (2021) indicate that a flexible, inert, y-shaped, medical-grade silicone IUD design prevented pregnancies in all the domestic mares that retained the device, even when exposed to fertile stallions. Domestic mares in that study lived in large pastures, mating with fertile stallions. Biweekly ultrasound examinations showed that IUDs stayed in 75% of treated mares over the course of two breeding seasons. The IUDs were then removed so the researchers could monitor the mares' return to fertility. In that study, uterine health, as measured in terms of inflammation, was not seriously affected by the IUDs, and most mares became pregnant within months after IUD removal. The overall results are consistent with results from an earlier study (Daels & Hughes, 1995), which used O-shaped silicone IUDs. Similarly, a flexible IUD with three components connected by magnetic force (the 'iUPOD') was retained over 90 days in mares living and breeding with a fertile stallion; after IUD removal, the majority of mares became pregnant in the following breeding season (Hoopes et al., 2021).

IUDs are considered a temporary fertility control method that does not generally cause future sterility (Daels & Hughes, 1995). Use of IUDs is an effective fertility control method in women, and IUDs have historically been used in livestock management, including in domestic horses. Insertion of an IUD can be a very rapid procedure, but it does require the mare to be temporarily restrained, such as in a squeeze chute. IUDs in mares may cause physiological effects including discomfort, infection, perforation of the uterus if the IUD is hard and angular, endometritis, uterine edema (Killian et al., 2008), and pyometra (Klabnik-Bradford et al., 2013). In women, deaths attributable to IUD use may be as low as 1.06 per million (Daels & Hughes, 1995). The effects of IUD use on genetic diversity in a given herd should be comparable to those of other temporary fertility control methods; use should reduce the fraction of mares breeding at any one time but does not necessarily preclude treated mares from breeding in the future, as they survive and regain fertility.

The exact mechanism by which IUDs prevent pregnancy is uncertain, but may be related to persistent, low-grade uterine inflammation (Daels & Hughes, 1995; Gradil et al., 2021; Hoopes et al., 2021), Turner et al. (2015) suggested that the presence of an IUD in the uterus may, like a pregnancy, prevent the mare from coming back into estrus. However, some domestic mares did exhibit repeated estrus cycles during the time when they had IUDs (Killian et al., 2008; Gradil et al., 2019; Lyman et al., 2021; Hoopes et al., 2021). The main cause for an IUD to not be effective at contraception is its failure to stay in the uterus (Daels & Hughes, 1995; NRC, 2013). As a result, one of the major challenges to using IUDs to control fertility in mares on the range is preventing the IUD from being dislodged or otherwise ejected over the course of daily activities, which could include, at times, frequent breeding.

At this time, it is thought that any IUD inserted into a pregnant mare may cause the pregnancy to terminate, which may also cause the IUD to be expelled. For that reason, it is expected that IUDs would only be inserted in non-pregnant (open) mares. Wild mares receiving IUDs would be checked for pregnancy by a veterinarian prior to insertion of an IUD. This can be accomplished by transrectal palpation and/or ultrasound performed by a veterinarian. Pregnant mares would not receive an IUD. Only a veterinarian would apply IUDs in any BLM management action. The IUD is inserted into the uterus using a thin, tubular applicator similar to a shielded culture tube, and would be inserted in a manner similar to that routinely used to obtain uterine cultures in domestic mares. If a mare has a zygote or very small, early phase embryo, it is possible that it would fail to be detected in screening, and may develop further, but without causing the expulsion of the IUD. Wild mares with IUDs would be individually marked and identified, so that they can be monitored occasionally and examined, if necessary, in the future, consistent with other BLM management activities.

Using metallic or glass marbles as IUDs may prevent pregnancy in horses but can pose health risks to domestic mares (Nie et al., 2003; Turner et al., 2015; Freeman & Lyle, 2015). Marbles may break into shards (Turner et al., 2015), and uterine irritation that results from marble IUDs may cause chronic, intermittent colic (Freeman & Lyle, 2015). Metallic IUDs may cause severe infection (Klabnik-Bradford et al., 2013).

In domestic ponies, Killian et al. (2008) explored the use of three different IUD configurations, including a silastic polymer O-ring with copper clamps, and the "380 Copper T" and "GyneFix" IUDs designed for women. The longest retention time for the three IUD models was seen in the "T" device, which stayed in the uterus of several mares for 3-5 years. Reported contraception rates for IUD-treated mares were 80%, 29%, 14%, and 0% in years 1-4, respectively. They surmised that pregnancy resulted after IUD fell out of the uterus. Killian et al. (2008) reported high levels of progesterone in non-pregnant, IUD-treated ponies.

Soft or flexible IUDs may cause relatively less discomfort than hard IUDs (Daels & Hughes, 1995). Daels and Hughes (1995) tested the use of a flexible O-ring IUD, made of silastic, surgical-grade polymer, measuring 40 mm in diameter; in five of six breeding domestic mares tested, the IUD was reported to have stayed in the mare for at least 10 months. In mares with IUDs, Daels and Hughes (1995) reported some level of uterine irritation but surmised that the level of irritation was not enough to interfere with a return to fertility after IUD removal.

More recently, several types of soft or flexible IUDs have been tested for use in breeding mares. When researchers attempted to replicate the O-ring study (Daels & Hughes, 1995) in an USGS / Oklahoma State University (OSU) study with breeding domestic mares, using various configurations of silicone O-ring IUDs, the IUDs fell out at unacceptably high rates over time scales of less than 2 months (Baldrighi et al., 2017; Lyman et al., 2021). Subsequently, the USGS / OSU researchers tested a Y-shaped IUD to determine retention rates and assess effects on uterine health; retention rates were greater than 75% for an 18-month period, and mares returned to good uterine health and reproductive capacity after removal of the IUDs (Holyoak et al., 2021). These Y-shaped silicone IUDs are considered a pesticide device by the EPA, in that they work by physical means (EPA, 2020). It is possible that some individual mares may become permanently infertile as a result of IUD use, even after IUD removal or expulsion; however, available evidence indicates that flexible IUDs should be considered a reversible fertility control method for most mares. The University of Massachusetts has developed a magnetic IUD that has been effective at prolonging estrus and preventing pregnancy in domestic mares (Gradil et al., 2019; Joonè et al., 2021; Gradil et al., 2021; Hoopes et al., 2021). After insertion in the uterus, the three subunits of the device are held together by magnetic forces as a flexible triangle. A metal detector can be used to determine whether the device is still present in the mare. In an early trial, two sizes of those magnetic IUDs fell out of breeding domestic mares at high rates (Holyoak et al., 2021), but more recent trials have shown that the magnetic IUD was retained even in the presence of breeding with a fertile stallion (Hoopes et al., 2021). The magnetic IUD was used in two trials where mares were exposed to stallions, and in one where mares were artificially inseminated; in all cases, the IUDs were reported to stay in the mares without any pregnancy (Joonè et al., 2021; Gradil et al., 2021; Hoopes et al., 2021).

References: Intrauterine Devices (IUDs)

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Effects of and SOPs for Use of Global Positioning System (GPS) Telemetry for Wild Horses and Burros

The purpose of this document is to describe methods that would be used for fitting Global Positioning System (GPS) radio collars on wild horse mares and wild burro jennies, or GPS tail tags on wild horses, and describe the expected possible effects for mares and jennies wearing radio collars. This document does not include methods for restraint, care, and maintenance of animals during gathers, while in captivity, or for any other handling procedures beyond those needed for fitting a radio collar.

It is now common to use radio collars fitted with VHF transmitters, GPS recorders, or satellite transmitters to obtain and record data on animal movement and other activities. Therefore, use of this technology can assist in collection of more detailed information for monitoring. Understanding the daily life of the focal species can lead to improvements in animal behavior and ecological knowledge (King, 2013). While most radio collars are considered to be minimally invasive, they can impose some cost on the animal carrying them. Thus, guidelines have been developed for a weight ratio (a collar should not exceed 5% of the animal's body weight) and best practice in their use (Sikes et al., 2011). Collars have the potential to cause injury to the animal wearing them, but when the collar is fitted correctly and monitored regularly it can provide invaluable data without any measurable impact on the collared or tagged animal.

Telemetry collars have been used extensively on carnivores (Germain et al., 2008; Creel & Christianson, 2009; Hunter et al., 2010; Broekhuis et al., 2013), rodents (Koprowski et al., 2007), and some ungulates (Johnson et al., 2000; Creel et al., 2005; Ito et al., 2005; Allred et al., 2013; Buuveibaatar et al., 2013; Latombe et al., 2013). However, in the time period until approximately 2010 they were not as commonly used on equids (Hennig et al., 2020). Several studies have used this method to examine habitat use, movements, and behavior of zebra (Fischhoff et al., 2007; Sundaresan et al., 2007; Brooks & Harris, 2008) and Asiatic wild asses (Kaczensky et al., 2006, 2008, 2011; Giotto et al., 2015). Before 2010, fewer published studies had used telemetry collars on feral equids (Committee on Wild Horse and Burro Research, 1991; Asa, 1999; Goodloe et al., 2000; Hampson et al., 2010), and additional studies on feral equids have become available to document their safety and use, as noted below.

Some studies have been conducted on wild horse and burro use of vegetation and habitat, based on methods that do not record animal locations directly (Beever & Brussard, 2000). It can be beneficial to resource managers to have a more detailed understanding of local wild equid seasonal habitat use and movements on public lands. Due to the scale of some Herd Management Areas (HMAs) or complexes of HMAs, it can be logistically challenging to collect unbiased habitat use data via direct visual observation. Using GPS and VHF collars for marking and locating individuals can provide fine-scale monitoring data about where wild animals spend their time and how they use their habitat, based on locations that are recorded throughout the day and night.

From March 2015 through March 2016, researchers at the U.S. Geological Survey (USGS) conducted a year-long preliminary study on captive wild horses and burro jennies to determine proper fit and wear of radio collars (Schoenecker et al., 2020). The condition of wild horses wearing radio collars was compared to non-collared controls and documented with photographs. In addition, the behavior of both collared individuals and controls was recorded for one hour daily, in order to quantify any impact of the collar on their behavior and health. At the end of the study period (March 2016) the collars were removed (Schoenecker et al., 2020).

Radio collars consist of a ~2-inch-wide strap/belt made of soft pliable plastic-like material (Figure N-1). Some collars are oval shaped with adjustments on both sides of the collar, and others are teardrop shaped with adjustments at the top of the collar so it can be fitted to different neck sizes. This is the most optimal shape for the neck of equids. Attached to the belt of the collar is a battery pack and transmitter module. These may either be combined in the same unit or placed at the top and bottom of the collar to counterbalance each other. The size of the battery is determined by the amount of power needed, both in terms of length of deployment, and how much data would be recorded by the collar. The type of transmitter used would depend on the monitoring goals, but all principles stated here for collar fitting and use apply regardless of communication systems used.

Radio collars used on BLM-managed wild horses or burros would include two pathways to cause the collar to fall off the animal. Collar drop-off happens when a mechanical device releases, so that the loop of the collar is no longer continuous. First, every collar would have a programmed drop-off date of, for example 2-3 years after the fitting date. The precise duration until the timed drop-off would depend on the battery life; programmed drop-off date would be before the end of the expected battery life. Second, every radio collar would include a manually triggerable drop-off option. A user with the appropriate UHF signaling device can send a signal to the collar, causing it to drop off. To ensure that the radio collar is not causing any physical injuries, the BLM would aim for every radio-collared horse or burro to be located and visually observed at least once every 4-6 weeks, by a BLM employee or trained person from a designated cooperating agency or organization. If there is any concern about physical damage caused by a collar, the BLM employee or BLM cooperating group's observer would use the UHF signal to cause the collar to drop off.

Collars can be placed on horses' or burros' necks when they are in a padded squeeze chute. It takes between 7 and 12 minutes to properly fit a collar on the animal. The transmitter should be functioning and turned on before the collar is fitted, then checked to ensure that the VHF signal is working correctly before the animal is released. GPS tags can be braided into wild horse tails and held in place with low temperature curing epoxy (Schoenecker et al., 2020; King & Schoenecker, 2022).

Fitting of the collar or tag

Details on radio collar fitting in horses are in Schoenecker et al. (2020). Fitting a collar requires an understanding of the neck circumference and shape; that is, when the head of the animal is raised the collar should be tight, and when the head is down grazing the collar would become looser (Figures O-2, O-3). The collar should rest just behind the ears of the equid and be tight enough, so it does not slip down the neck, yet loose enough that it does not interfere with movement when the neck is flexed. The collar must fit snugly to minimize rubbing. USGS researchers used 0-1 finger spacing (of an average sized adult human) between collar and neck, depending on the season the collar is deployed to give consideration to the potential for weight gain. Other studies (Committee on Wild Horse and Burro Research, 1991) have had problems with the fitting of collars due to animals gaining weight in spring, or losing weight in winter, causing collars to become too tight or too loose. In the USGS study, researchers did notice collars were looser or tighter at different times during the year, but it did not affect the behavior of collared mares or jennies, or cause sores or wounds on mares or jennies. Whenever collars are deployed, they should be fitted by experienced personnel who can attach the collar quickly but proficiently to minimize handling stress on the animal.

No effects are expected from the tags; however, it is possible that they may form an irritation to individuals should vegetation get tangled in the tail. In this case it is expected that the tag would ultimately rip out of the hair (leaving no injury) as the horse rubs it. Details on tag fitting in horses are in Schoenecker et al. (2020).

Impacts of the Use of Radio Collars

Based on numerous studies that have used modern radio collars with remote releases and tags to monitor wild ungulates and equids in particular, these devices have minimal effects on the animals wearing them. The impact of radio collars and tags is very minimal and tends to last only as long as the animal has the collar or tag. From March 2015 through March 2016 researchers at the USGS conducted a preliminary study on captive wild horses and burro jennies to determine proper fit and wear of radio collars (Schoenecker et al., 2020). The condition of wild horses and burros wearing radio collars was compared to non-collared controls and documented with photographs. In addition, both collared individuals and controls were observed for 80 minutes each week for 14 weeks in order to quantify any impact of the collar on their behavior and health. At the end of the study period (March 2016) the collars were removed. Preliminary analyses indicate that mares and jennies had almost no impact in terms of rubbing or wear from radio collars and behavior of collared and uncollared mares did not differ (Schoenecker et al., 2020). The same authors also examined effects of a braid-in tail tag, which also had no negative impacts, but which cannot be used on burros because their tails are relatively hairless, compared to horses (King & Schoenecker, 2022). If new data are published from more recent studies, the procedures for use of collars and tail tags may be updated accordingly. The BLM has supported other ecological studies in which wild mares and jennies living on-range were radio collared with similar collars and were monitored for health and any effects of collars via monthly welfare checks. Such collars, with the timed and remotely triggerable drop-off mechanisms, have been used in Adobe Town, Conger, Eagle, Frisco, Swasey, and Sulphur HMAs (mares) and in Sinbad HMA and Lake Pleasant HMA (jennies). The timed and remote-release drop off mechanisms have proven safe for use; the same authors who urged researchers to report any problems with equid radio collars in Hennig et al. (2020) have not reported such problems in their subsequent papers (Hennig et al., 2018; Esmaileh et al., 2021; Hennig et al., 2021; Hennig et al., 2022; King et al., 2022), nor did Karish et al (2023).

There are some possible effects from the use of collars. On rare occasions, a collar over an ear has been observed, and this seems more common on collared stallions (Schoenecker et al., 2020). On stallions, radio collars may cause sores (Schoenecker et al., 2020), though Popova et al. (2023) did not report any health concerns in collared stallions. No stallions or jack burros would be collared in any of the action alternatives in this EA. Also, collars may be fitted too tightly, or a horse or burro may grow, tightening the collar. If neck abrasions or sores caused by a collar are observed and have not healed within 4 weeks of when it is observed, the collar’s remote release would be deployed, or the horse or burro would be captured as soon as possible to remove the collar. If these situations are observed, the triggerable remote-release function would be deployed remotely. If that remote release failed, the collar would be removed after capturing the animal through approved methods in the Proposed Action. Although collars may cause fur matting and minor hair loss (Schoenecker et al., 2020), notable neck abrasions or sores on mares or jennies have not been reported in papers about studies where equids have been collared (Collins et al., 2014; Hennig et al., 2018; Esmaileh et al., 2021; Hennig et al., 2021; Hennig et al., 2022; King et al., 2022).

The use of collar and tag technology in monitoring may help with understanding how free- roaming horses move across the HMAs and use increasingly scarce resources. Applying this technology in free-roaming horses and burros could provide the opportunity to better monitor resource use, individual foaling rates, habitat preference, home range and movement patterns. Such information may or may not be useful in informing future management decisions.

Figure N-1. Two collar designs to use on wild horses and burros; one is teardrop shaped, and the other is oval shaped from Collins et al. (2014).

Figure N-2. Burro jenny fitted with a radio collar in the USGS study (Schoenecker et al., 2020) showing appropriate placement of collars higher on the neck, behind ears.

Figure N-3. Wild horse mares fitted with radio collars in the USGS study (Schoenecker et al., 2020) showing head up and head down behavior and demonstrating appropriate placement of collars higher on the neck just behind the ears.

References: Global Positioning System (GPS) Telemetry

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